



Washington State School Seismic Safety Assessments Project

SEISMIC ASSESSMENT REPORT

Seismic Screening Data Figures
WA School Maps & School Selection
Phase 1 & Phase 2 Risk Prioritization
OSPI ICOS Data for EPAT
Economic Considerations
FEMA Reference Docs

June 2021

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WASHINGTON STATE SCHOOL SEISMIC SAFETY ASSESSMENTS PROJECT

SEISMIC ASSESSMENT REPORT

VOLUME 1 OF 5

June 2021

Prepared for:

State of Washington
Department of Natural Resources and Office of Superintendent of Public Instruction

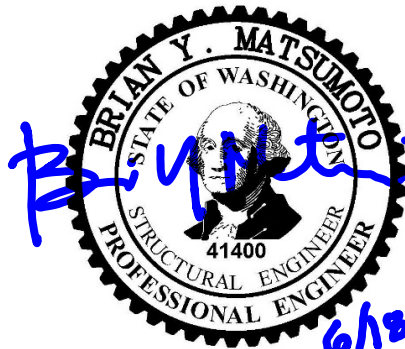
Volume 1: Seismic Assessment Report

Volume 2: EPAT and FEMA P-154 RVS Forms

Volume 3: ASCE 41-17 Screening Reports

Volume 4: Seismic Upgrades Concept Design Reports, 17 School Buildings

Volume 5: Seismic Upgrades Concept Design Reports, 2 Fire Stations



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EXECUTIVE SUMMARY

There are 295 K-12 public school districts throughout Washington State serving approximately 1.1 million students. In these school districts, over 4,400 buildings are recognized as permanent school buildings, of which approximately 70 percent are in high-risk seismic areas. In 2017, Washington State took a major step to improve the understanding of seismic risks to public K-12 school buildings by funding the first phase of a statewide seismic study in the 2017-2019 Washington State capital budget called the Washington State School Seismic Safety Project (SSSP).

This Phase 2 project is the continuation and second phase of the SSSP and includes the seismic assessment of 339 school buildings and 2 fire stations, most of which are located in the highest seismic hazard areas of Washington State. Similar to Phase 1, the seismic assessments include ASCE 41 Tier 1 evaluations, FEMA P-154 Rapid Visual Screening (RVS), and Washington Schools Earthquake Performance Assessment Tool (EPAT) screenings for each school building. In addition, 17 school buildings and 2 fire stations were selected to receive individual conceptual seismic upgrade reports that include recommendations for seismic upgrades with associated construction cost estimates. The Department of Natural Resources Washington Geological Survey (DNR-WGS) also conducted soil shear wave velocity testing and determined the soil site class for each school campus that was used for the ASCE 41 seismic screenings and conceptual seismic upgrade reports.

The following are the engineering recommendations resulting from this study:

Recommendations to Enhance School Seismic Safety

- Require seismic upgrades when schools undergo major modernizations.
- Increase seismic performance criteria for the design of new school buildings.
- Develop a long-term program to seismically upgrade or replace vulnerable existing school buildings.
- School districts can use this study's EPRS structural safety sub-rating results to prioritize seismic deficiencies for retrofit.
- Consider funding incentives specifically for seismic upgrades that are included in nonstructural maintenance projects.
- Study and mimic best-practices of seismic safety programs in other western states.
- Develop state program to inform communities and school districts about seismic safety and resiliency.

Recommendations for Further Studies

- Conduct benefit-cost analysis on high priority school buildings.
- Continue updating OSPI's ICOS database and doing ASCE 41 seismic evaluations of school buildings.
- Further study soil liquefaction risks at school sites.

Recommendations for Fire Stations

- Consider grant program similar to the School Seismic Safety Grant Program that will assist in seismically upgrading vulnerable fire stations.
- Further study the state's inventory of fire stations to better-determine seismic upgrade needs.

The results from Phase 1 of the SSSP indicated that Washington State has many older school buildings that are vulnerable to earthquakes. The results further indicated that many of these older buildings consist of construction types known to be especially vulnerable to earthquake such as unreinforced masonry buildings (URM), non-ductile concrete buildings, and older pre 1960 reinforced masonry buildings. Phase 2 further confirms these Phase 1 findings. In total, both phases have only screened approximately 12 percent of the stock of permanent school buildings in the state. Meaning there are many other older and seismically vulnerable school buildings in the state that still need attention to determine what can and should be done to improve seismic safety.

Although mitigating all of the state's oldest school buildings right away may not be possible or financially feasible, especially considering other safety hazards and immediate facility needs for schools, many organizations are taking incremental steps to increase the seismic safety of our schools. Many of Washington's policy makers, school districts, and design professionals are actively turning seismic knowledge into action. Following the Phase 1 report, the State Legislature funded the Office of Superintendent of Public Instruction (OSPI) \$13 million for a School Seismic Safety Retrofit Grant Program (SSSRP), the first of its kind in Washington State. This grant program is underway in seismically upgrading select school buildings. The State Legislature has since approved another \$38 million for the 2021-2023 biennium for this grant program.

Incremental investments to seismically improve Washington's older and seismically vulnerable public school buildings will save lives, and protect students and teachers. Seismic improvements will also save money in the long-run and increase the resiliency of our state and communities. Enhancing the seismic safety and performance of school buildings does not require an all-or-nothing approach. It can affordably be accomplished through voluntary seismic upgrades and incremental seismic upgrades that are incorporated into modernizations and improvements that would otherwise only be nonstructural in nature. A significant portion of this study's estimated seismic upgrade costs are related to the fact that the seismic upgrades often require the removal and replacement of existing finishes and nonstructural systems. The seismic upgrade cost estimates prepared in this study demonstrate that the costs can be significantly reduced when they are combined with nonstructural improvements, potentially reducing costs by upwards of 70 percent. Enhancing the seismic safety of our schools in this manner would be more affordable and have a wider reaching impact on school buildings across our region.

The results and findings of this study should be used to inform the State Legislature and policy makers of the estimated seismic risks in K-12 public school buildings statewide and be given consideration when coming up with policies and funding mechanisms to mitigate them. The screening reports, concept reports, and structural safety risk information provided by this study should be used by OSPI, the school districts, and the fire departments to develop mitigation strategies and seismic improvement projects of school buildings and fire stations (either done

voluntarily or as part of a modernization) or to serve as guidance in providing further engineering investigation and analysis. Additionally, further study of the liquefaction risks at building sites, benefit-cost analyses on high-priority buildings, and efforts to continue seismically screening buildings and updating OSPI's Information and Condition of Schools (ICOS) database, will further prepare our state for earthquakes.

The SSSP (Phases 1 and 2) has been an incredible opportunity to study and evaluate school buildings across the state and has demonstrated the need for dedicated funding for seismic retrofits. The cost of inaction on improving seismic safety is too great for our children, parents, teachers, and communities. Although the state has taken strides in earthquake awareness and preparedness, there is still a great deal more work to be done. Washingtonians, through further awareness and support of their communities and school districts, can provide the necessary investments needed to improve seismic safety and improve our community infrastructure across the state.

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Acronyms

ASCE	American Society of Civil Engineers
BPOE	Basic Performance Objective for Existing Buildings
BSE	Basic Safety Earthquake
BU	Built-Up
CMU	Concrete Masonry Unit
CP	Collapse Prevention
CSZ	Cascadia Subduction Zone
DCR	Demand-to-Capacity Ratio
DNR	Department of Natural Resources
EPRS	Earthquake Performance Rating System
EERI	Earthquake Engineering Research Institute
EPAT	Earthquake Performance Assessment Tool
FEMA	Federal Emergency Management Agency
IBC	International Building Code
ICOS	Information and Condition of Schools
IO	Immediate Occupancy
LFRS	Lateral Force-Resisting System
LS	Life Safety
LTD-S	Limited Safety
MCE	Maximum Considered Earthquake
NIST	National Institute of Standards and Technology
OSPI	Office of Superintendent of Public Instruction
OP	Operational
PBEE	Performance-Based Earthquake Engineering
PGA	peak ground acceleration
PR	Position Retention
RM	Reinforced Masonry
RVS	Rapid Visual Screening
SEAONC	Structural Engineers Association of Northern California
SSSP	Washington State School Seismic Safety Project
SSSSC	Washington State School Seismic Safety Steering Committee
UBC	Uniform Building Code
URM	Unreinforced Masonry
USRC	US Resiliency Council
WF	Wide Flange
WGS	Washington Geological Survey

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We would also like to acknowledge the structural engineering consultant team consisting of Reid Middleton, WRK Engineers, WSP USA, and DCI Engineers; our architectural consultant team consisting of Rolluda Architects and Dykeman Architects; our cost estimating services provided by ProDims; geotechnical engineering contributions provided by GeoEngineers; and economic considerations provided by ECONorthwest.

It is the project team's sincere hope that this information will be valuable to the Governor, State Legislators, state agencies, school districts, school administrators, teachers, students, parents, and the public. We hope it will help these groups to better understand the current level of seismic risk to Washington State public school buildings. We hope this information can be helpful in improving school seismic safety and resiliency.

1.0 Introduction

1.1 Project Overview

There are 295 K-12 public school districts throughout Washington State serving approximately 1.1 million students. In these school districts, over 4,400 buildings are recognized as permanent school buildings, of which approximately 70 percent are in high-risk seismic areas. In 2011, Washington State took the initial step with the Washington State School Seismic Safety Pilot Project to help determine an appropriate method to assess the earthquake performance of school buildings to be able to recommend future courses of action (Walsh et. al, 2011). In 2017, Washington State took another major step to improve the understanding of seismic risks to public K-12 school buildings by funding the first phase of a statewide seismic study in the 2017-2019 Washington State capital budget called the Washington State School Seismic Safety Project (SSSP).

Phase 1 of the SSSP, led by the Department of Natural Resources Washington Geological Survey (DNR-WGS), was completed in June 2019 and seismically assessed 222 school buildings and 5 fire stations. Phase 1 also provided conceptual seismic upgrades design reports for 15 school buildings across the state that included construction cost estimates with the intent of extrapolating it to the inventory of older school buildings across the state. The goal of Phase 1 was to provide a better understanding of the seismic risk of older Washington State public school buildings and to help estimate the fiscal needs to improve and upgrade existing school buildings to be seismically safe.

This project is the continuation and second phase (referred to as Phase 2 herein) of the Phase 1 statewide study. Phase 2 has a very similar scope and objective to Phase 1 and includes the seismic assessment of 339 school buildings and 2 fire stations, most of which are located in the highest seismic areas of the state. Similar to Phase 1, the seismic assessments include ASCE 41 Tier 1 evaluations, FEMA P-154 Rapid Visual Screening (RVS), and Washington Schools Earthquake Performance Assessment Tool (EPAT) screenings for each school building. In addition, 17 school buildings and 2 fire stations were selected to receive individual conceptual seismic upgrade reports that include recommendations for seismic upgrades with associated construction costs estimates. DNR-WGS also conducted soil shear wave velocity testing and determined the soil site class for each school campus.

In Phase 2, buildings were again selected using the Office of Superintendent of Public Instruction's (OSPI) database of permanent buildings with a primary focus on older school buildings in high seismic areas. The Phase 2 selection criteria is based on the conclusions of the Phase 1 assessments project and prioritized buildings in high seismic areas, older buildings (e.g., prior to the adoption of the statewide building code in 1975), and buildings of vulnerable construction types (such as unreinforced masonry and nonductile concrete buildings). There was also a preference given to buildings that had original construction drawings (i.e., blueprints) or other information available to aid in the assessments. Even so, a significant portion of selected buildings only had partial or no construction drawings available for review.

This Seismic Assessment Report supplements DNR-WGS’s Final Report to the State and includes the structural engineering findings, recommendations, and individual screenings of the buildings assessed in Phase 2 of the SSSP.

WASHINGTON STATE SCHOOL SEISMIC SAFETY FACTS

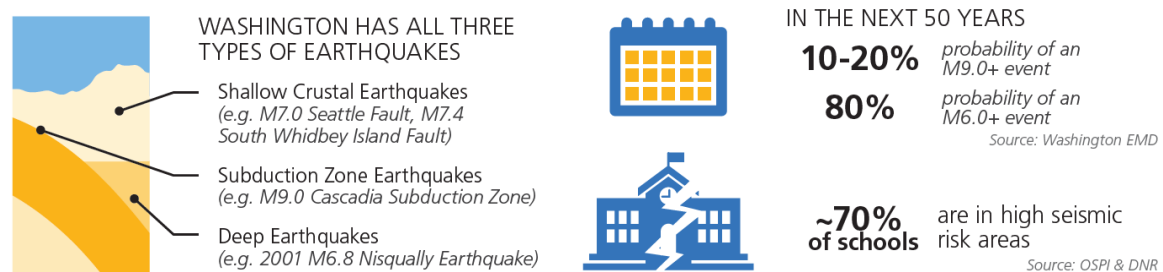


Figure 1.2-1. Washington State School Seismic Safety Facts.

1.2 Project Objective

The overall goal of the SSSP is to continue the statewide school seismic safety initiatives currently being led by the School Seismic Safety Steering Committee (SSSSC) that includes DNR-WGS, OSPI, Emergency Management Division (EMD), and professors from the University of Washington school of Civil Engineering. The initiatives of the SSSSC were to seismically evaluate a representative sample of school buildings across the state, use the geologic and seismic evaluation results to determine costs to seismically upgrade buildings, and then extrapolate the costs to similar school buildings throughout Washington State to determine what it may cost to complete these seismic assessments statewide.

To support these initiatives, Phases 1 and 2 of the SSSP set out with the following objectives:

- Perform seismic screenings of representative school buildings to assess the seismic safety of public K-12 buildings in Washington State (561 school buildings or roughly 12 percent of the permanent building stock) and for a select number of fire stations within one mile of a public K-12 school.
- Perform assessments of site-specific geology to determine the seismic site class of the soils at these school campuses.
- Use the findings of the buildings screened in Phase 1 and Phase 2 to provide a prioritized list of schools based on geologic and engineering results.
- Develop high-level cost estimates to retrofit a prioritized subset of seismically vulnerable school buildings and fire stations.
- Gather building data for OSPI’s Information and Condition of Schools (ICOS) database.
- Share and communicate the information and findings gathered with the State and school districts.

In building upon the work completed in 2019 for Phase 1 of the SSSP, Phase 2 set out to use the results and findings of the seismic screenings to provide the state and school districts with:

- A translation of the ASCE 41 Tier 1 seismic evaluation checklist to an easier to understand structural safety rating.
- A prioritized list of the 561 school buildings screened as part of the SSSP that are grouped by severity of seismic risk (very high, high, moderate, and lower risks).

The primary intent of the SSSSC initiatives and SSSP objectives are to utilize the information gathered, and the findings and recommendations of the project team, to inform the Washington State Legislature and policy makers of the current level of estimated seismic risks in K-12 public school buildings statewide. This information should help guide long-term strategies and policies for improving the seismic safety of our state's older school buildings. The secondary intent is to provide each participating school district the seismic screening results and related seismic safety improvement recommendations to help inform their long-term capital planning and budgeting efforts.

Achieving the project objectives of Phase 2 required very similar project steps taken in Phase 1 as described by Figure 1.3-1. Defining and selecting the school buildings for assessment was a significant effort, as will be discussed in Section 2.4 of this report. Once the buildings were selected, engineering teams consisting of licensed structural engineers visited each building to visually observe the condition of the building and perform cursory field investigations to confirm information gathered from existing building drawings. In cases where existing building drawings were not available, these site visits by the engineers served to determine the construction type of the school buildings. Engineers then used the findings from their site visit and their review of existing building drawings to perform a seismic evaluation and prepare a screening report for each building. Of the 561 school buildings screened in Phases 1 and 2, seventeen school buildings were then selected to receive conceptual seismic upgrades design reports and cost estimates. Results and findings from the screening reports, conceptual upgrades reports, and cost estimates were then compiled into this seismic engineering assessment report that supplements DNR-WGS's Final Report that goes to the Office of Financial Management and the appropriate committees of the State Legislature, in accordance with the 2019-2021 Capital Budget appropriation.



Figure 1.3-1. Basic Project Steps.

1.3 Project Team

Reid Middleton, Inc., is the prime consultant contracted by the DNR-WGS, in partnership with OSPI and the SSSSC. As the prime contractor for Phases 1 and 2 of the SSSP, Reid Middleton worked with and coordinated directly with the DNR-WGS, OSPI, and the school districts in performing the seismic assessments of the school buildings and fire stations, gathering all of the data and performing data analytics, facilitating the prioritization and recommendations for seismically upgrading school buildings, and the authoring of this report.

Structural Engineering: Reid Middleton partnered with and led teams from three other structural engineering firms heavily experienced in seismic engineering and with the design and retrofit of school buildings and fire stations. The intent of this partnership was to provide DNR, OSPI, and school districts with distributed access to experienced experts and licensed structural engineers throughout the state of Washington – experts invested in and a part of the communities and regions around them. The structural engineering team consists of licensed structural engineers from **Reid Middleton, Inc.** (based in Everett, WA); **WRK Engineers, Inc.** (located in Vancouver, WA); **WSP, USA** (who subsequently acquired BergerABAM at the end of Phase 1, located in Federal Way, WA); and **DCI Engineers, Inc.** (the Spokane office, located in Spokane, WA).

Architecture: The architecture team consists of two architecture firms, **Dykeman Architects** (located in Everett, WA) and **Rolluda Architects, Inc.** (located in Seattle, WA). Both architecture firms are highly experienced in K-12 public school work and provided general guidance and consideration of the architectural aspects of the conceptual seismic upgrade designs.

Cost Estimating: The cost estimating of the conceptual seismic upgrades was provided by **ProDims, LLC** (Kirkland, WA). ProDims is experienced in estimating K-12 public school work, and also projects in the Pacific Northwest in general, including numerous seismic retrofit projects.

Geotechnical Engineering: Geotechnical engineering considerations provided in this report were provided by **GeoEngineers, Inc.**, headquartered in Redmond, Washington. Although GeoEngineers was not involved with the geologic data gathering, shear wave velocity analysis, and site class determination performed by DNR-WGS, they were consulted by the structural engineering project team for considerations and input related to earthquake induced soil liquefaction.

Economics: Economic considerations in Section 6.0 and Appendix B.5 were provided by **ECONorthwest** (Seattle, WA). ECONorthwest has experience with other large studies in the Pacific Northwest region related to seismic resiliency. ECONorthwest provided consultation to the structural engineering team regarding benefit costs analyses, economics, and policy and planning for agencies and businesses with limited resources.

1.4 Tasks Performed by the Structural Engineering Contractor

The project was accomplished in several distinct and overlapping phases of work, which included: assistance in the school building selection for this study; school facilities research and information review; field investigations and data collection; seismic screenings; concept-level seismic upgrades design and cost estimating; data analyses and entry; findings and recommendations and reporting. The following tasks were performed by Reid Middleton, Inc., as the structural engineering contractor for the state, and their subconsultant team of engineers, architects, cost estimators, geotechnical engineers, and economists.

1.4.1 School Selection Process

The WGS lead the school selection process for the Phase 2 project. The Washington State Legislature wrote criteria into the 2019-2021 Capital Budget for which schools should be prioritized for participation in the study. In following this, the WGS prioritized the following buildings for inclusion in the study:

- A sample of public facilities located in high-priority areas as determined in Phase 1 of the SSSP and in tsunami inundation zones as published by the Department. The survey used the results of the SSSP Phase 1 findings to prioritize school buildings based on geologic and engineering results.
- A portion of public school facilities that are routinely used for the instruction of students in K-12 grade and in school districts that have held successful bond elections within the previous three years.
- A portion of the remaining public school facilities that are routinely used for the instruction of students in kindergarten through twelfth grade.

DNR-WGS and OSPI took the first step in the selection process and sought out school districts interested in participating in this study, with the request that they also have existing building drawings available for use in the seismic screening assessments. Many of the school districts contacted initially were those that are located in the high-seismic areas of the state and those that have passed a successful bond election within the previous three years in accordance with the requirements of the Capital Budget.

As school districts responded to DNR-WGS and OSPI's request, the project team searched through school building inventory records from OSPI's ICOS database to identify the oldest buildings in the interested school districts as candidates for seismic screening. The project team then contacted the school districts to:

- Confirm participation in this study.
- Confirm the availability of existing structural and architectural drawings of the building candidates and request they be sent to the project team digitally (if digital drawings were available).

- Inquire about the current use of the school buildings that were being considered for seismic screenings.
- Inquire about any past seismic work already performed on the building candidates or modernization work in progress.

The project team then reviewed the existing building drawings provided by school districts to prioritize school buildings with an adequate level of structural or architectural drawings that could be used to effectively perform the ASCE 41 Tier 1 screenings. This initial drawing review also allowed the project team to see the screening candidates' construction type, which was then used as another consideration based on the previous Phase 1 study's findings.

In addition to the availability of adequate drawings, the selection process also prioritized buildings that matched the Phase 1 study's findings that the highest risk schools are:

- Located in high seismic hazard areas in the state.
- Have buildings that are older (particularly those built prior to 1975 when the state adopted a building code).
- Have buildings that are the more-seismically vulnerable construction types such as unreinforced masonry (URM), non-ductile concrete, and older reinforced masonry buildings.

Many buildings beyond the 339 buildings selected for Phase 2 were considered during the selection process. Significant effort was extended in contacting the school districts to understand their desire to participate and to obtain, review and vet existing building drawings for adequacy. Some school districts chose not to participate, and several school districts were not responsive to contact attempts. Ultimately, school buildings that met the legislative requirements, had adequate existing building drawings, and were located in school districts that wanted to participate were readily selected. This criteria was also balanced with the selection of buildings that met the legislative requirements, but did not have building drawings. Only 63 percent of selected buildings ended up having original structural drawings available for review. In many cases, the most seismically vulnerable older school buildings (e.g. URM and non-ductile concrete buildings) are also the buildings that do not have existing drawings due to the difficulty of keeping records from that long ago. The project team attempted to balance all of the desirable features listed above to select buildings that met the needs of the project and allowed for project completion in a timely manner.

1.4.2 Selected Schools

A complete list of the 339 school buildings selected for seismic screening in Phase 2 is in Appendix B.2, along with a map of the participating school districts in Phases 1 and 2 of the SSSP.

Figure 1.4-1 is a statewide map showing the Phase 1 school buildings, Phase 2 school buildings, and the other permanent school buildings not studied in Phase 1 or Phase 2. The 561 buildings assessed in Phases 1 and 2 are a small sample (~12 percent) of the entire school building stock. Note that in total 561 buildings have been assessed, at 274 schools, on 245 campuses (multiple schools can share the same campus). The engineers performed seismic assessments at each

individual building (561 buildings total for Phases 1 and 2), whereas the geologic site assessments are performed at each school campus (245 campuses total for Phases 1 and 2).

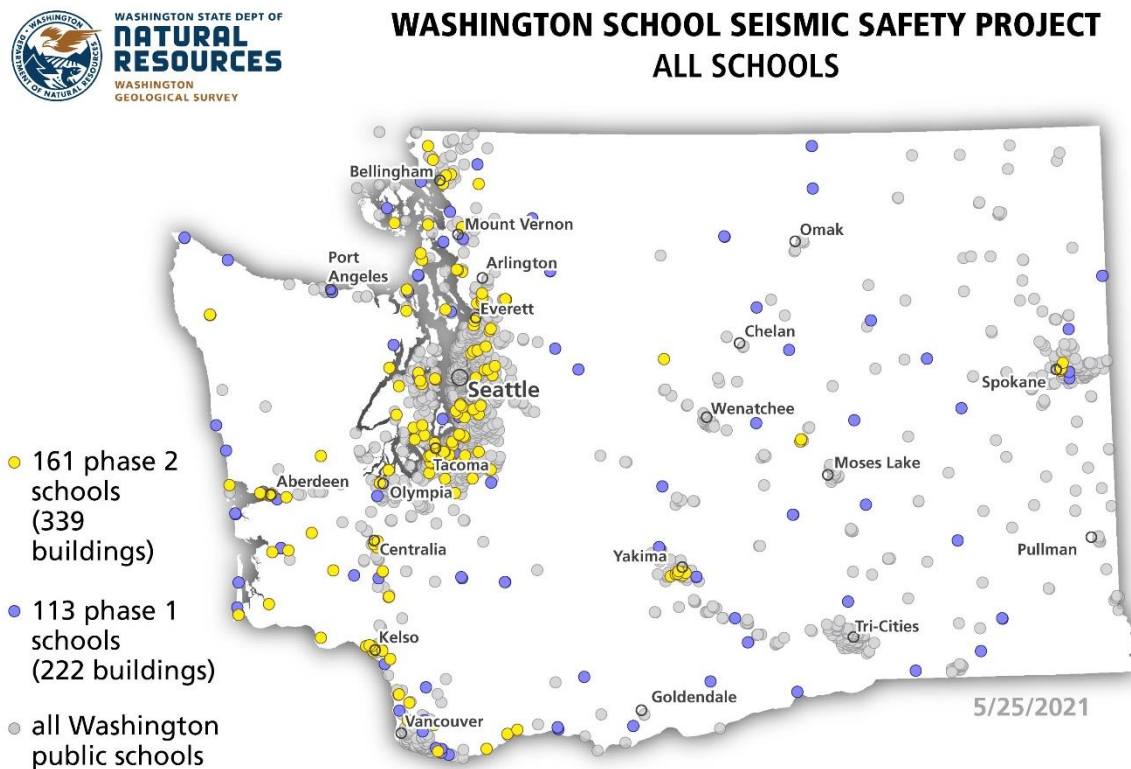


Figure 1.4-1. Map showing the schools assessed for Phase 1 and Phase 2 of this project as well as the locations for all other public K-12 Washington schools. (Courtesy WGS).

It is important to note that a sizeable portion of the school selection process happened in the spring of 2020, at the beginning stages of school shutdowns and quarantines due to COVID-19. This hampered some school districts' ability to locate existing drawing records or dedicate staff in support of the project team's efforts, considering that their priority and focus was on implementing new and unfamiliar safety measures in their facilities. As a result, some school districts chose not to participate in this study. This was a significant hurdle in the school selection process and in finalizing the school selection list. Consequently, in addition to COVID-19 related challenges in general, this longer than anticipated selection process also presented additional scheduling challenges in the field-investigation phase of this study.

1.4.3 Research and Information Review

As previously mentioned, the project team researched and reviewed school building drawings that were provided by school districts as part of the school selection process. This research included contacting the school districts to obtain building plans, seismic reports, condition reports, or related construction information useful for the project. Some school districts had this information readily available digitally, while other school districts only had hardcopies available

at the school district offices. There were also some school districts that did not have any original structural or architectural drawings of the selected buildings on record.

Significant effort was spent collecting and scouring through existing building drawings (blueprints) and databases provided by the school districts. Existing building structural drawings are essential for conducting the structural seismic evaluations because most structural elements are not visible during field investigations. For buildings assessed in Phase 2, 63 percent had a full set of structural drawings, 20 percent had partial drawing sets (some with only partial architectural drawings), and 17 percent had no drawings available whatsoever.

OSPI also assisted with the documentation they have on record, which includes previous condition assessments and area plans from their Study and Survey initiatives that are used to populate their ICOS database. Where existing construction drawings were not available, this information became extremely valuable for engineers in understanding the building systems and construction history, especially for older buildings that have undergone a number of modernizations, upgrades, and additions over the years. Many of these types of school buildings have multiple additions that are interconnected and contain a variety of structural systems and construction materials.

1.4.4 Field Investigations and Data Collection

Field Investigation Coordination: The project team coordinated the field investigation schedule with the DNR/WGS, OSPI, and the participating school districts to obtain access to the site and minimize disruption to building occupants. The scheduling coordination with school districts was heavily impacted by the COVID-19 pandemic.

The majority of the field investigation site visits were performed from May 2020 through December 2020 while students were out of school buildings with remote learning or on summer vacation. COVID-19 safety and sanitation were of utmost importance to the team of engineers visiting the schools and for the teachers and facility staff working in the buildings during the engineers' site visits. Appropriate safety, protection, and disinfection measures were taken during the field investigations and engineers followed school district COVID protocols before entering school buildings. The project team also kept a site visit log to document dates and locations of the field investigation site visits, the engineering personnel who performed the field investigation site visits, and the self-screening assessments made prior to visiting the schools.

Field Investigations: The project team performed site visits at each of the selected school buildings to observe the building's condition, configuration, and structural system for the purposes of the ASCE 41 Tier 1 seismic screening evaluations. This task included confirmation of general information included in building records or layout drawings (when available) and visual observations of the condition of the structure.

The field observations at each site were limited to areas and building elements that were observable and safely accessible. Observations requiring access to confined spaces, potential hazardous material exposure, use of an unsecured ladder, work around energized electrical equipment or mechanical hazards, areas requiring OSHA fall-protection, steep or unstable slopes, deteriorated structural assemblies, or other field conditions deemed to be potentially

unsafe by the engineer were not performed. Removal of finishes (e.g., gypsum board, lath and plaster, brick veneer, or roofing materials) for access to concealed conditions or to expose elements that cannot otherwise be visually observed and assessed, along with material sampling and testing, was beyond the scope of this project.

Data Collection: The ASCE 41 Tier 1 seismic screening checklists, EPAT spreadsheets, and RVS forms were used to document the year of construction, year of any structural renovations, presence of existing structural drawings, the building construction type, descriptions of the building systems, overall condition, relative seismic risk level, structural and nonstructural seismic deficiencies, and horizontal and vertical structural irregularities. The data gathered was organized and transmitted to OSPI for input into the ICOS database for future reference and use in their pre-disaster preparedness and mitigation plans.

Geologic Data Coordination: The project team incorporated the geologic shear wave velocity results and determination of site-specific soil site class into the building seismic evaluations and OSPI ICOS database.

1.4.5 Seismic Evaluations, Screenings, and Conceptual Seismic Upgrades Designs

ASCE 41 Tier 1 Seismic Evaluations: The project team performed ASCE 41-17 Tier 1 structural and nonstructural seismic screening evaluations of the 339 school buildings and two fire stations using the *ASCE 41-17 Seismic Evaluations and Retrofit of Existing Buildings* Tier 1 Seismic Screening Procedures. The seismic evaluations are part of the individual seismic screening reports for each building and are included in Volume 3 of this report.

FEMA P-154 Rapid Visual Screening: FEMA P-154 Rapid Visual Screenings (RVS) were completed for each building using the methodology found in FEMA P-154 Rapid Visual Screening of Buildings for Potential Seismic Hazards. The individual RVS forms are included in Volume 2 of this report.

Washington Schools Earthquake Performance Assessment Tool: The Washington Schools Earthquake Performance Assessment Tool (EPAT) spreadsheet published by the Earthquake Engineering Research Institute (EERI) was completed for each school. The spreadsheet tool uses the FEMA HAZUS methodology to identify likely earthquake damage, life safety risk and likelihood building is repairable. The individual EPAT worksheets are included in Volume 2 of this report.

Conceptual-Level Seismic Retrofit/Upgrade Designs: Based on the results of Tier 1 seismic screening evaluations, the project team selected 17 school buildings and 2 fire stations that received conceptual-level seismic retrofit and upgrade design reports. The concept-level seismic upgrades design reports are based on the ASCE 41 Tier 1 seismic screenings and include narrative descriptions of the recommended seismic retrofit or upgrade schemes, concept design sketches depicting the extent and type of recommended structural upgrades, and opinions of probable costs. The individual concept-level seismic upgrades reports are included in Volumes 4 and 5 for the selected school buildings and fire stations respectively.

Cost Estimating: The project team prepared opinions of probable costs of the conceptual-level seismic retrofit or upgrade designs for each of the 17 selected school buildings and 2 fire stations. These school buildings are intended to be representative samples of the state's vulnerable school buildings in high-seismic areas. The intent of the cost estimates is to extrapolate costs developed as part of this study to other similar types of school buildings in the state and use these costs to help estimate at a high-level the capital needs for seismically upgrading Washington State's most seismically vulnerable schools.

1.4.6 Data Analyses and Entry

SEAONC Earthquake Performance Rating System: Preliminary structural safety star ratings were developed for each Phase 1 and Phase 2 school building using the Structural Engineers Association of Northern California (SEAONC) Earthquake Performance Rating System (EPRS). The structural safety star ratings were developed using only the ASCE 41 Tier 1 checklists as input. Geologic checklist items were excluded from the rating due to insufficient information. The structural safety star ratings are included in the individual seismic screening reports in Volume 3 of this report.

Data Analytics: Data from the building seismic screening evaluations, EPAT worksheets, and concept-level seismic upgrade cost estimates were processed and organized in charts and figures to communicate the findings and trends in the data. These charts and figures are included in the body of this report and in Volume 1, Appendix B.1.

Seismic Screening Evaluation Data Upload: Data from the building seismic screening evaluations were provided to OSPI's ICOS building inventory database for future use and reference with OSPI's Washington Schools EPAT spreadsheets. The data provided is tabulated in Volume 1, Appendix B.4.

Prioritized Rankings of Phase 1 and Phase 2 School Buildings by Relative Risk: Phase 1 and 2 school buildings were scored and grouped into categories that prioritize buildings for seismic retrofit by relative risk. Engineering judgment was used to assign buildings to one of four categories: Very High Priority, High Priority, Moderate Priority, and Lower Priority. The prioritized grouping of school buildings seismically screened in Phase 1 and Phase 2 of this study is tabulated in Volume 1, Appendix B.3.

1.4.7 Reporting and Documentation

ASCE 41-17 Screening Reports: The project team documented the findings of the building seismic screening assessments in the form of a written report. Each building is documented by a standard report format that provides pertinent building information, a summary of the building's structural systems and overall condition, site photographs, EPRS structural safety rating, summaries of structural and nonstructural deficiencies, and ASCE 41-17 Tier 1 seismic screening checklists. The individual seismic evaluation screening reports for each building are included in Volume 3 of this report.

Conceptual-Level Seismic Upgrades Design Reports: For each of the 17 school buildings and 2 fire stations selected to receive conceptual-level seismic upgrades design reports, the project

team prepared stand-alone reports that include an abbreviated background of this study, seismic evaluation criteria and procedures, a summary of the seismic screening evaluation, concept-level seismic retrofit/upgrade recommendations and sketches, and opinions of probable costs estimates. For the convenience of the end users of these reports, pertinent existing drawings used for the seismic screening and seismic upgrade recommendations are included as an appendix in this reports. Illustrative excerpts from FEMA E-74 *Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide* have also been included as an appendix as a quick reference guide in mitigating common nonstructural deficiencies.

Seismic Assessment Report: The project team has prepared this Seismic Assessment Report as part of DNR-WGS's final report to the Legislature. This report provides an overview of the structural engineering and seismic evaluation procedures used in this study, the seismic assessment findings and results, recommendations for enhancing seismic safety of school buildings and recommendations for future study.

1.5 Report Organization

Due to the voluminous nature of the data and information gathered for this project, this report has been organized into five separate volumes.

Volume 1: Seismic Assessment Report

Volume 2: EPAT and FEMA P-154 RVS Forms

Volume 3: ASCE 41-17 Screening Reports

Volume 4: Seismic Upgrades Concept Design Reports, 17 School Buildings

Volume 5: Seismic Upgrades Concept Design Reports, 2 Fire Stations

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2.0 Earthquake Hazards and Washington State School Overview

2.1 Washington State Seismic Hazards

Washington can experience all three major types of earthquakes: deep intraplate earthquakes, shallow surface fault earthquakes, and subduction zone earthquakes. Each of these types of earthquakes present their own types of hazards and risks.

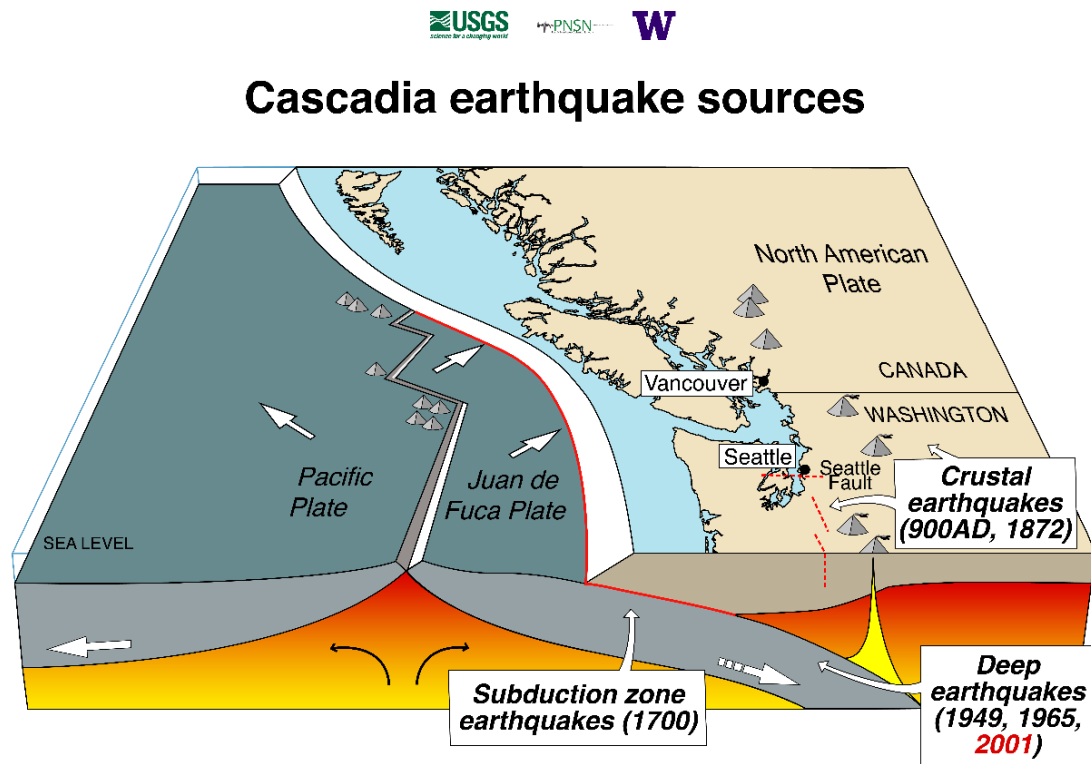


Figure 2.2-1. Cascadia Earthquake Sources (U.S. Geological Survey, Pacific Northwest Seismic Network, University of Washington).

Historically, deep intraplate earthquakes have occurred most frequently (1949 Olympia Earthquake, 1965 Puget Sound Earthquake, 2001 Nisqually Earthquake). These earthquakes typically occur within Washington State about every 30 to 50 years. While the death toll from these earthquakes has been relatively small compared to other natural disasters, they have caused substantial infrastructure damage that has required time and money to repair. However, the other types of earthquakes that can occur in Washington have a potential to be much more devastating.

Washington State has many active surface seismic faults (WA DNR, 2019). Most of the known surface faults within Washington State exist on the Olympic Peninsula, in the Puget Sound Region, in areas near Bellingham, Washington, in the Cascade Mountain Range, near Yakima, Washington, near the Tri-Cities area, and in southeastern Washington. There are relatively few known faults in north-central and northeastern Washington. Surface faults within Washington

State are expected to cause the largest local ground accelerations out of the three major types of earthquakes. The largest of these earthquakes are expected to possess moment magnitudes varying between 6.8 and 7.4 and peak spectral accelerations are expected to exceed 1.0 g near the epicenter of many of these surface fault earthquakes (USGS, 2019).

WHAT IS A DESIGN-LEVEL EARTHQUAKE?

A “design-level earthquake” is a theoretical earthquake event, which is defined in ASCE 7-16 as being two-thirds of the magnitude of the maximum considered earthquake (MCE_R). The MCE_R is a risk-adjusted probabilistic event with a return period of 2,475 years. The earthquake level is adjusted with the intent that new buildings designed to the current building code will have a 1% probability of collapse in 50 years due to a seismic event (ASCE 41-17, 2017). While not exact, the magnitude of the design-level earthquake event is similar to the magnitude of an earthquake event with a 475-year return period for many locations on the west coast of the United States. Earth scientists expect the average return period of a Cascadia Subduction Zone (CSZ) earthquake to be approximately 500 years. It is possible that a CSZ earthquake could be approximately the magnitude of the design-level earthquake for many parts of Washington State, depending on the particular earthquake characteristics. Engineers and building officials select a design-level earthquake to either design a new building or to check an existing building to predict its resilience to earthquake shaking. The design-level earthquake is mandated by the building code to represent the earthquake shaking hazards for the region where the building is located; this includes shaking from large earthquakes, such as the Cascadia subduction zone, but also shaking hazard from active crustal faults such as the Seattle fault or the Southern Whidbey Island fault zone. It is used in the design of buildings to ensure that the building behaves in a predictable way if that design-level earthquake event should occur.

In addition to the two types of earthquakes listed above, Washington State can also experience subduction zone earthquakes produced by the Cascadia Subduction Zone (CSZ) off the coast of Western Washington. Subduction zones are known to produce earthquakes with magnitudes around and exceeding 9.0. Scientists have discovered evidence of 19 CSZ earthquakes in the last 10,000 years with an average return period of approximately 500 years (USGS, 2012). From a geologic perspective, these earthquakes occur at quite regular intervals. The most recent CSZ earthquake is believed to have occurred on January 26, 1700 (Satake, et al, 1996). A large magnitude earthquake on the CSZ is expected to affect areas from British Columbia, Canada, all the way to Northern California, with Washington and Oregon being heavily affected in between. While a CSZ earthquake is expected to affect the entirety of the state of Washington, the local ground shaking in locations such as Port Angeles, Seattle, Olympia, or Yakima are expected to be smaller for a CSZ event compared to surface fault ruptures with earthquake epicenters located close to each of those locations.

2.2 Local vs. State-Level Seismic Hazards

The different types of seismic faults and different types of earthquakes that can occur in Washington State affect the ways state and local governments must plan for these different earthquake events. Deep intraplate earthquakes occur the most frequently but tend to be the least damaging type of earthquake. While these earthquakes can cause costly damage that must be repaired, these earthquakes typically do not require significant state-level or national resources in order to recover. The fact that Washington State has experienced three deep intraplate earthquakes since 1949 may lead Washingtonian’s to think that the earthquake risk in Washington State is not very high. However, shallow surface fault earthquakes and Cascadia Subduction Zone earthquakes are expected to be different.

Large-magnitude, shallow-surface fault earthquakes of magnitudes between 6.8 and 7.4 are expected to dramatically affect the local area around the epicenters of these earthquakes. For example, if the Tacoma Fault, Seattle Fault, Southern Whidbey Island Fault, or Wallula Fault were to have a large rupture, this would likely cause the largest possible expected ground shaking close to their epicenters (WA DNR, 2019). For each of these examples, the cities of Tacoma, Seattle, Everett, the Tri-Cities Area, and their surrounding areas would be most greatly affected, respectively. While each of these cities would be devastated in these respective scenarios, areas of the state further than 50 miles away would likely only be minimally affected. While these earthquakes would be locally devastating close to their epicenters, and it is important for local cities and Washington State to prepare for their eventual rupture, the rupture of these faults will not cause high ground shaking that extends across the entire state. In addition to these four example surface faults, there are many other surface faults within Washington State. While it is likely prudent for local city governments to be most concerned about the high ground shaking that can occur from a local surface fault rupture, the state government must be sufficiently prepared to respond to both local surface fault ruptures and also ruptures on the Cascadia Subduction Zone.

In contrast to deep intraplate earthquakes and shallow surface fault earthquakes, a large magnitude earthquake (~9.0) on the Cascadia Subduction Zone fault is expected to greatly affect the entirety of Washington. The earthquake on this fault is expected to cause the largest shaking and a tsunami on Washington's western coast with decreasingly large shaking in central and eastern Washington (WA DNR, 2013). From a statewide planning perspective, a large magnitude Cascadia Subduction Zone earthquake is likely to utilize the most state and federal resources out of all the known seismic hazards in Washington State.

2.3 Washington State Schools Overview

The state of Washington OSPI's ICOS database contains a list of 4,476 recognized permanent school buildings. The 339 selected schools are a subset of the school buildings listed in the current ICOS database. In overall numbers, the 339 school buildings represent about eight percent of the statewide school buildings. The 561 buildings evaluated in Phase 1 and Phase 2 comprise approximately 12 percent of the statewide school buildings. The average area of each school building is 25,000 square feet, with an average student population of approximately 380 students per building. The average year of construction of these buildings is 1963, and 75 percent of these buildings are one-story structures.

According to OSPI, approximately 1.1 million students are enrolled in our state's public schools and taught by more than 64,000 classroom teachers. These students and teachers are housed in approximately 4,476 permanent and 5,524 non-permanent buildings across the state within 295 public school districts. Approximately 70 percent of these school buildings are considered to be in high-risk seismic areas, with about 11 percent located in medium-risk seismic areas. Of this 70 percent of buildings in high-risk seismic areas, over 700 school buildings are recorded in ICOS as being built before 1960 averaging 33,000 square feet per building. ICOS also has records that indicate approximately 300 of the older school buildings have had modernizations done over the years, however the extent of the work entailed, or more importantly, the extent of past seismic upgrades performed, is not currently captured in ICOS. Capturing seismic upgrade

that are done voluntarily or as part of a modernization is a recommendation further discussed in section 7.0.

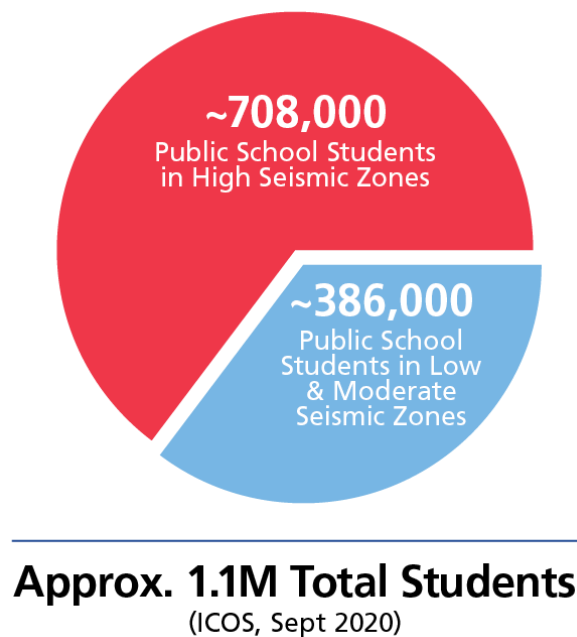


Figure 2.3-1. Distribution of Public School Students in High vs. Moderate/Low Seismic Hazard Areas per OSPI ICOS Database (2020).

2.4 Effects of Liquefaction on the Seismic Risk of Schools Buildings

A detailed geotechnical and liquefaction analysis of the site soils was not included in the scope of this study. As a result, the geotechnical seismic effects on the existing buildings assessed in the study, such as the presence of liquefiable soils and allowable soil bearing pressures, are unknown at this time.

Liquefaction, when it occurs, drastically decreases the soil bearing capacity and leads to large differential ground deformations of soil between building foundations and across the building footprint. Liquefaction can also cause soils to spread laterally and can dramatically affect a building's response to earthquake motions, all of which can significantly compromise the overall stability of the building and possibly lead to isolated or widespread collapse in extreme cases. Existing foundations damaged as a result of liquefiable soils also make the building much more difficult to repair after an earthquake.

Buildings that are not founded on a raft foundation or deep foundation system (such as grade beams and piles), and those with conventional strip footings and isolated spread footings that are not interconnected well with tie beams, are especially vulnerable to liquefiable soils. Mitigation techniques used to improve structures in liquefiable soils vary based on the type and amount of

liquefiable soils and may include ground improvements to densify the soil (aggregate piers, compaction piling, jet grouting), installation of deep foundations (pin piling, augercast piling, micro-piling), and installation of tie beams between existing footings.

Current data in the ICOS database includes liquefaction susceptibility based on publicly available statewide liquefaction maps on DNR's Washington Geologic Information Portal (<https://www.dnr.wa.gov/geologyportal>). However, these maps were constructed at a large predictive scale that may not be appropriate for site-specific use in identifying the presence of liquefiable soils at a particular school site. To reliably assess the effects of liquefaction-induced ground deformations, additional geologic and geotechnical information will be needed to augment the shear wave velocity measurements obtained as part of this study. Further recommendations are provided in Section 7.0.

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3.0 Seismic Evaluation Procedures

3.1 Performance-Based Earthquake Engineering

The seismic evaluation of building structures is based on performance-based earthquake engineering (PBEE) guidelines presented in ASCE 41-17 *Seismic Evaluation and Retrofit of Existing Buildings* (American Society of Civil Engineers, 2017). A general background of PBEE and an overview of seismic retrofit objectives, seismic hazard levels, seismic performance levels, and seismic evaluation and retrofit procedures are included in this section.

PBEE can be defined as the engineering of a structure to resist earthquake demands while also meeting the needs and objectives of school building owners and other stakeholders. PBEE allows for the design and analysis of building structures for different levels of seismic performance and allows these different levels of seismic performance to be related to the relative seismic hazard.

Historically, the seismic analysis and design of school buildings traditionally focused on one performance level: reducing the risk for loss of life in a design-level earthquake (life safety). The concept of designing essential facilities, such as hospitals, fire stations, and high-occupancy shelters, which are needed immediately after an earthquake, to a higher performance standard evolved after hospitals and other critical facilities were severely damaged in the 1971 San Fernando earthquake in California. That concept of more resilient design is balanced by the recognition that the cost of retrofitting existing buildings to higher levels of seismic performance may be onerous to both stakeholders and policy makers.

3.1.1 Overview of the ASCE 41-17 Seismic Standard

A comprehensive federal program was started in 1991, in cooperation with FEMA, to develop guidelines tailored to address the variation of seismic design performance levels. The first formal applications of performance-based seismic evaluation and design guidelines were the FEMA 310 *Handbook for the Seismic Evaluation of Buildings – A Prestandard* (1998) and FEMA 273 *NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (1997). Following the release of these documents in the 1990s, three additional documents were released in the following years. Another prestandard document, FEMA 356 *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*, was released in the year 2000.

In 2003, the first national standard seismic evaluation document, ASCE 31-03 *Seismic Evaluation of Existing Buildings*, was published. Following the release of ASCE 31-03, the first national standard seismic rehabilitation document, ASCE 41-06 *Seismic Rehabilitation of Existing Buildings*, was released in 2007. ASCE 31-03 and ASCE 41-06 superseded the PBEE documents produced in the previous decade. ASCE 31-03 and ASCE 41-06 used the general framework outlined by previous documents but were updated to incorporate the latest standard of PBEE at the time.

ASCE 31-03 and ASCE 41-06 still had flaws and, soon after the release of ASCE 41-06, an effort was undertaken to combine ASCE 31-03 and ASCE 41-06 into a single national standard

document in an attempt to streamline the documents and eliminate discrepancies. ASCE 41-13, *Seismic Evaluation and Retrofit of Existing Buildings*, combines information from all of the previous documents, reflects advancements in technology and analysis techniques, and incorporates case studies and lessons learned from recent earthquakes. The newest version of this national standard is the updated ASCE 41-17, *Seismic Evaluation and Retrofit of Existing Buildings*, published in 2017.

ASCE 41-17 provides criteria by which existing school buildings can be seismically screened, evaluated, and retrofitted to attain a wide range of different performance levels when subjected to earthquakes of varying severity. This is the seismic screening standard that was used as the basis for this project.

3.1.2 Seismic Hazard Levels

Earthquake ground motions are variable and complicated, and every earthquake is different. An earthquake's intensity and energy magnitude depend on fault type, fault movement, depth to epicenter, and soil strata. In earthquake-prone areas, often very small and frequent earthquakes occur every few days or weeks without being noticed by humans, but large earthquakes that occur much less frequently can have a devastating effect on infrastructure and buildings and can result in the temporary displacement of large amounts of people. Earthquakes are unpredictable, and the precise location, intensity, and start time of an earthquake cannot be predicted before an event occurs. However, earthquake hazards for certain geographic areas are well understood based on historical patterns of earthquakes from the geologic record, measured earthquake ground motions, understanding of plate tectonics, and seismological studies.

Geologists, seismologists, and geotechnical engineers have categorized the seismic hazard for particular locations using probabilistic seismic hazard levels. Each seismic hazard level describes a different probabilistic earthquake magnitude based on the probability of a certain magnitude earthquake occurring in a given time period. The table below shows the commonly used seismic hazard levels, their corresponding probabilities of exceedance, and mean return periods.

Table 3.1.2-1. Probabilistic Seismic Hazard Levels and Mean Return Period.

Seismic Hazard Level	Probability of Exceedance in 50 Years	Mean Return Period (Years)
50%/50-year	50%	72
20%/50-year (BSE-1E)	20%	225
10%/50-year	10%	475
5%/50-year (BSE-2E)	5%	975
2%/50-year	2%	2,475

Seismic events with longer mean return periods and smaller probabilities of exceedance are associated with stronger seismic motions, larger ground accelerations, and more potential to damage facilities. Consequently, structures designed, retrofitted, or upgraded to a seismic hazard level with a longer return period will generally experience better performance in an earthquake than a structure designed or retrofit to a lower seismic hazard level.

ASCE 41-17 codifies four different Seismic Hazard Levels at which to seismically screen, evaluate, and/or retrofit/upgrade school buildings and other structures. For voluntary seismic evaluations and voluntary seismic upgrades, the owner of a school and the structural engineer can decide the Seismic Hazard Level at which it is appropriate to evaluate or retrofit a structure.

Historically, existing buildings have been seismically evaluated and retrofitted to a lower Seismic Hazard Level than would be typical in new building design. This approach has been historically justified for three primary reasons:

- Ensures that recently constructed structures are not immediately rendered seismically deficient due to minor building code changes.
- Existing buildings often have a shorter remaining life than a new building would; therefore, lower structural resiliency is tempered by a decreased probability of a major seismic event.
- Often the burdensome cost of retrofitting historic structures to a “new building equivalence” performance level is disproportionate to the incremental benefit.

3.1.3 Building Performance Levels and Seismic Retrofit/Upgrade Options

A target building performance level must be selected for the seismic design of a retrofit or upgrade of a school building. The target building performance levels are discrete damage states selected from among the infinite spectrum of possible damage states that a building could experience during an earthquake. The terminology used for target building performance levels is intended to represent goals for design but not necessarily predict building performance during an earthquake.

Since actual ground motions during an earthquake are seldom comparable to that used for design, the target building performance level may only determine relative performance during most events but not predict the actual level of damage following an event. Even given a ground motion similar to that used in design, variations from stated performance objectives should be expected. Variations in actual performance could be associated with differences in the level of workmanship, variations in actual material strengths, deterioration of materials, unknown geometry and sizes of existing members, differences in assumed and actual live loads in the building at the time of the earthquake, influence of nonstructural components, and variations in response of soils beneath the building.

ASCE 41-17 describes performance levels for structural components and nonstructural components of a structure. Historically, much attention was given to the seismic performance of structural components. In more recent years, it has been realized that attention to the seismic performance of nonstructural components can be just as important as, or more important depending on the facility, than the seismic performance of structural components. The ASCE 41-17 standard identifies the following Structural Performance Levels: Immediate Occupancy (IO), Damage Control, Life Safety (LS), Limited Safety (LTD-S), and Collapse Prevention (CP). The nonstructural Performance Levels identified in the standard are: Operational (OP), Position Retention (PR), and Life Safety (LS). Figure 3.1.3-1 is an example of recent earthquake damage to a primary school in central Mexico.



Figure 3.1.3-1. Structural Earthquake Damage to a Primary School in Central Mexico from the 2017 M7.1 Central Mexico Earthquake (Photo by Reid Middleton).

Individual Structural Performance Levels and Nonstructural Performance Levels are aggregated to form a combined Building Performance Level. Structural performance during an earthquake is related to the amount of lateral deformation or drift of the structure and the capacity or ability of the structure to deform. The ASCE 41-17 standard defines four specific common Building Performance Levels, as illustrated in Figure 3.1.3-2.

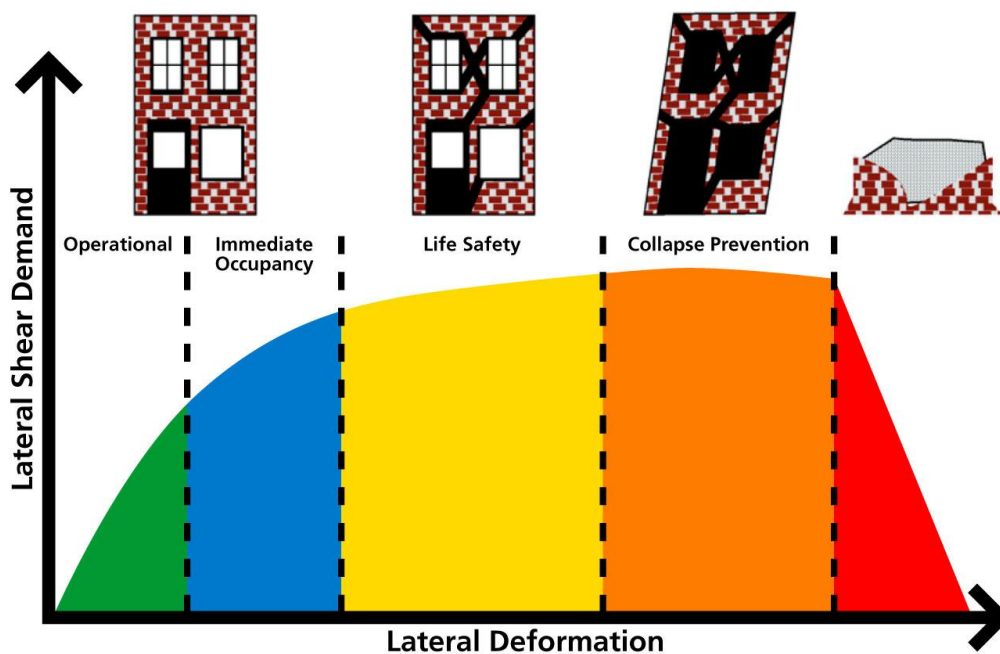


Figure 3.1.3-2. Building Performance Levels (FEMA).

A decision must be made for each building structure as to the acceptable behavior for different levels of seismic hazard, balanced with the construction cost of seismically retrofitting or upgrading a structure to obtain that behavior. ASCE 41-17 defines “baseline” basic performance objectives for structures based on their defined Risk Category. The Risk Category is the same as defined in the International Building Code (IBC) and ASCE 7.

Table 3.1.3-1 summarizes the approximate levels of structural and nonstructural damage that may be expected at the damage states that define the structural performance levels.

Table 3.1.3-1. Expected Damage for Different Building Performance Levels (FEMA 356, 2000).

	Building Performance Levels			
	Collapse Prevention (CP)	Life Safety (LS)	Immediate Occupancy (IO)	Operational (OP)
Overall Damage	Severe.	Moderate.	Light.	Very Light.
Permanent Drift	Large. 1% to 5%.	Some. 0.3% to 1%.	Negligible.	Same as Immediate Occupancy.
Remaining Strength and Stiffness After Earthquake	Little. Gravity system (columns and walls) functions, but building is near collapse.	Some. Gravity system functions, but building may be beyond economical repair.	Significant strength remaining. Minor cracking of structural elements.	Same as Immediate Occupancy.
Examples of Damage to Concrete Framing	Extensive cracking and spalling of concrete members. Crack widths greater than 1/4 inch.	Extensive cracking and spalling of concrete. Crack widths typically less than 1/4 inch and less than 1/8 inch in columns and joints.	Crack widths typically less than 1/8 inch and less than 1/16 inch in columns and joints.	Same as Immediate Occupancy.
Examples of Damage to Steel Framing	Extensive yielding and buckling of steel members. Significant connection failures.	Local buckling of steel beams and braces. Moderate amount of connection failures.	Minor deformation of steel members, no connection failures.	Same as Immediate Occupancy.
Other General Description	Structure likely not repairable and not safe for reoccupancy due to potential collapse in aftershock.	Repair may be possible but may not be economically feasible. Repairs may be required prior to reoccupancy.	Minor repairs may be required, but building is safe to occupy.	Same as Immediate Occupancy.
Nonstructural Components	Extensive damage. Some exits blocked. Infills and unbraced parapets failed or at incipient failure.	Falling hazards mitigated, but many architectural, mechanical, and electrical systems are damaged.	Minor cracking of facades, partitions, and ceilings. Equipment and contents are generally secure but may not operate due to lack of utilities.	Negligible damage. All systems important to normal operation are functional. Power and other utilities are available, possibly from standby sources.
Comparison with New Building Design	Significantly more damage and greater risk.	Somewhat more damage and slightly higher risk.	Much less damage and lower risk.	Much less damage and lower risk.

3.1.4 Performance, Safety, Reliability, and Construction Cost

The seismic performance, safety, and reliability of a facility must be weighed against the relative importance and construction costs associated with a facility. It is impractical for the average

building to be seismically designed or retrofitted to experience no damage following a major earthquake. However, steps can be taken to mitigate seismic hazards for new and existing structures.

Some facilities have more community importance or pose special risks to a community following an earthquake (for example, hospitals, fire stations, schools, or even facilities housing highly toxic substances). It is reasonable that important facilities be designed or retrofitted to a higher performance standard than the average structure. The relative importance of a facility must be weighed against the relative construction costs associated with facility construction. There are two types of construction costs associated with seismic hazards: the cost of initial construction or seismic retrofit construction and the costs to repair or replace a facility following an earthquake. The better a structure performs during an earthquake, the faster a structure can be returned to service and the less the repair costs will be for a structure following an earthquake. Building expected damage states during a seismic event can be directly linked to:

- Repair/Replacement Costs – Cost of restoring the facility to pre-earthquake condition.
- Public Safety – Number of critical injuries and casualties to building occupants.
- Downtime – Length of time taken to make repairs to return a structure back to service.

The graph in Figure 3.1.4-1 depicts estimated performance-related consequences compared with different increasing post-earthquake structural damage states (which correspond to the design Structural Performance Levels for a given seismic hazard).

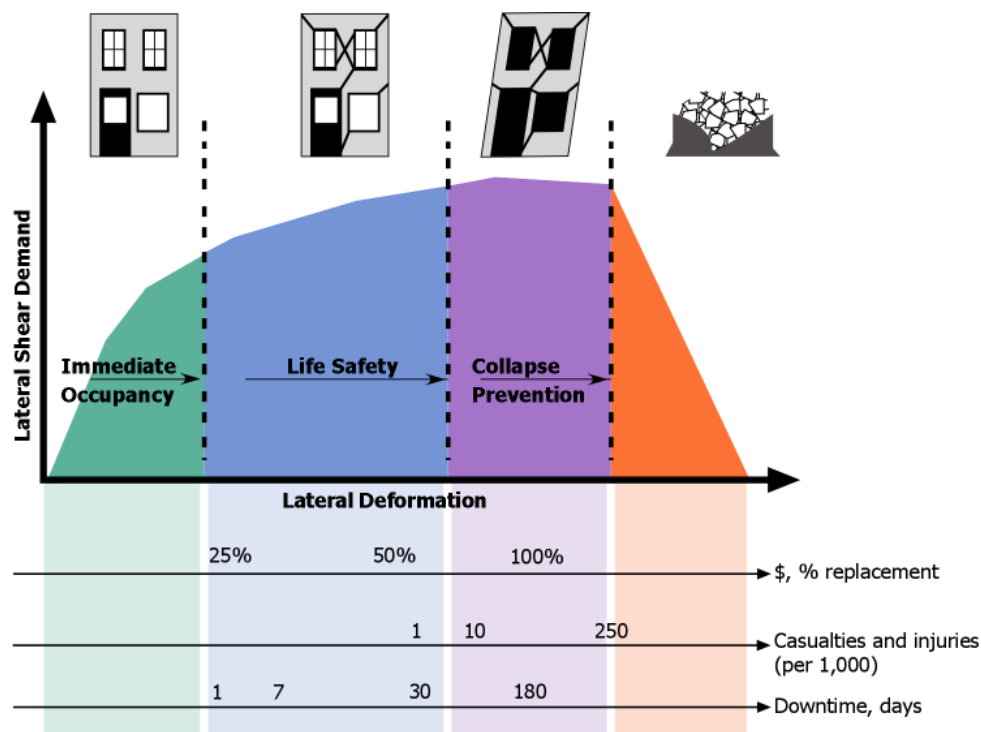


Figure 3.1.4-1. Estimated Seismic Performance-Related Consequences (Moehle, 2003)

Figure 3.1.4-2 presents the schematic relationship between different retrofit building performance objectives and the probable seismic retrofit/upgrade program cost.

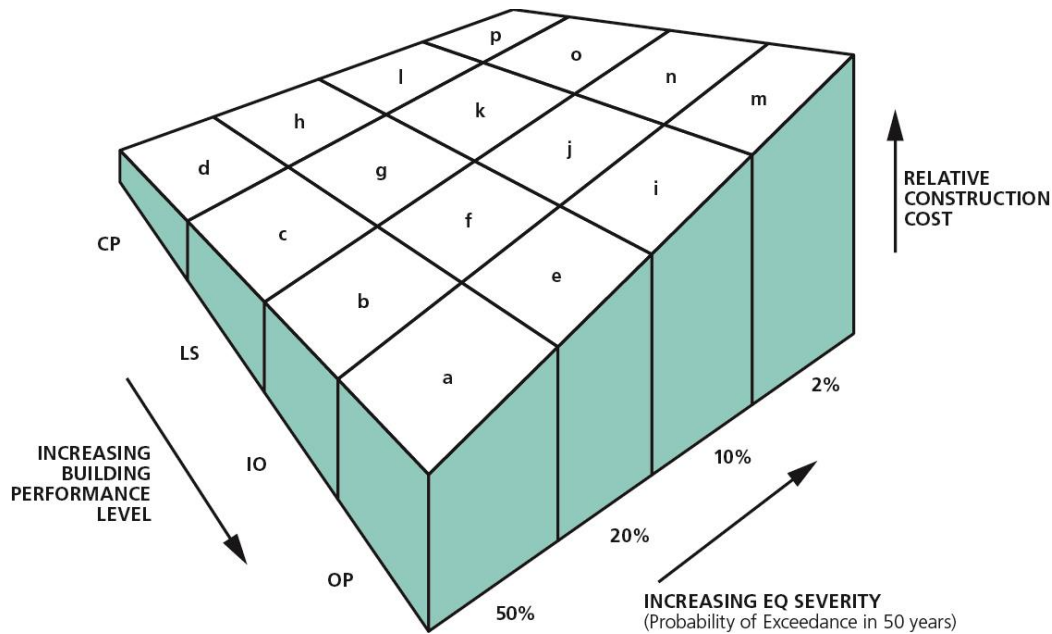


Figure 3.1.4-2. Surface Matrix of ASCE 41 Building Performance Levels Compared with Construction Cost (FEMA 274, 1997).

3.1.5 Seismic Performance of Nonstructural Components

Mitigation of nonstructural seismic hazards is a complex issue that is addressed independently in the ASCE 41-17 seismic evaluation and retrofit/upgrade standards. For much of the 20th century, little attention was given to designing nonstructural components and their anchorage for forces induced by earthquakes. Nonstructural component damage witnessed during earthquakes in more recent decades has demonstrated the importance of nonstructural component performance during earthquakes for life safety, post-earthquake safety, and building function.



Figure 3.1.5-1. Nonstructural Earthquake Damage to a High School in Anchorage, Alaska, from the 2018 M7.0 Anchorage Earthquake (Photo by Reid Middleton, Inc.).

In addition to the hazards to life safety posed by nonstructural components, the cost to repair nonstructural components following an earthquake can be high and significantly delay the reopening of a school or other facility. In many cases, the cost to repair or replace nonstructural components can be higher than the cost of repairing structural components following an earthquake.

WHAT DOES NON-COMPLIANT MEAN?

“The ASCE 41 Seismic Screening, Evaluation, and Upgrade Standard is used to evaluate the structural and nonstructural systems and components for any type or size of individual school building. However, the procedure focuses on evaluating whether the building or building components pose a potential earthquake-related risk to human life. The procedure does not address code compliance, damage control, or other aspects of seismic performance not related to life-safety. The methodology involves answering two sets of questions: one set addresses the characteristics of 15 common structural types and the other set deals with structural elements, foundations, geologic site hazards, and nonstructural components and systems. These questions are designed to uncover the flaws and weaknesses of a building and are in the form of positive evaluation statements describing building characteristics that are essential if the failures observed in past earthquakes are to be avoided. Compliant statements identify conditions that are acceptable and non-compliant statements identify conditions in need of further investigation.”

FEMA 424 Design Guide for Improving School Safety in Earthquakes, Flood and High Winds, 2010

The relative monetary importance of nonstructural components can be seen in Figure 3.1.5-2 by comparing the relative construction costs of the contents, nonstructural components, and structural components of three types of typical new buildings. In offices and hotels, the building nonstructural components cost the most to construct, by a significant margin. In hospitals, the costs of constructing the building contents and nonstructural components are similar, but still far exceed the cost of the building structural systems. Nonstructural construction costs for public school buildings would be comparable to office buildings in this particular FEMA E-74 study.

Many nonstructural components, if adequately secured to the structure, are seismically rugged. However, mitigation of some nonstructural hazards (such as bracing for mechanical and electrical components within suspended ceiling systems or the improvement of ceiling systems themselves) can result in extensive disruption of occupancy. Repairing or replacing these components following an earthquake can also be very costly. These costs and benefits need to be taken into consideration when determining desired nonstructural performance levels and the goals of any seismic evaluation or retrofit/upgrade.

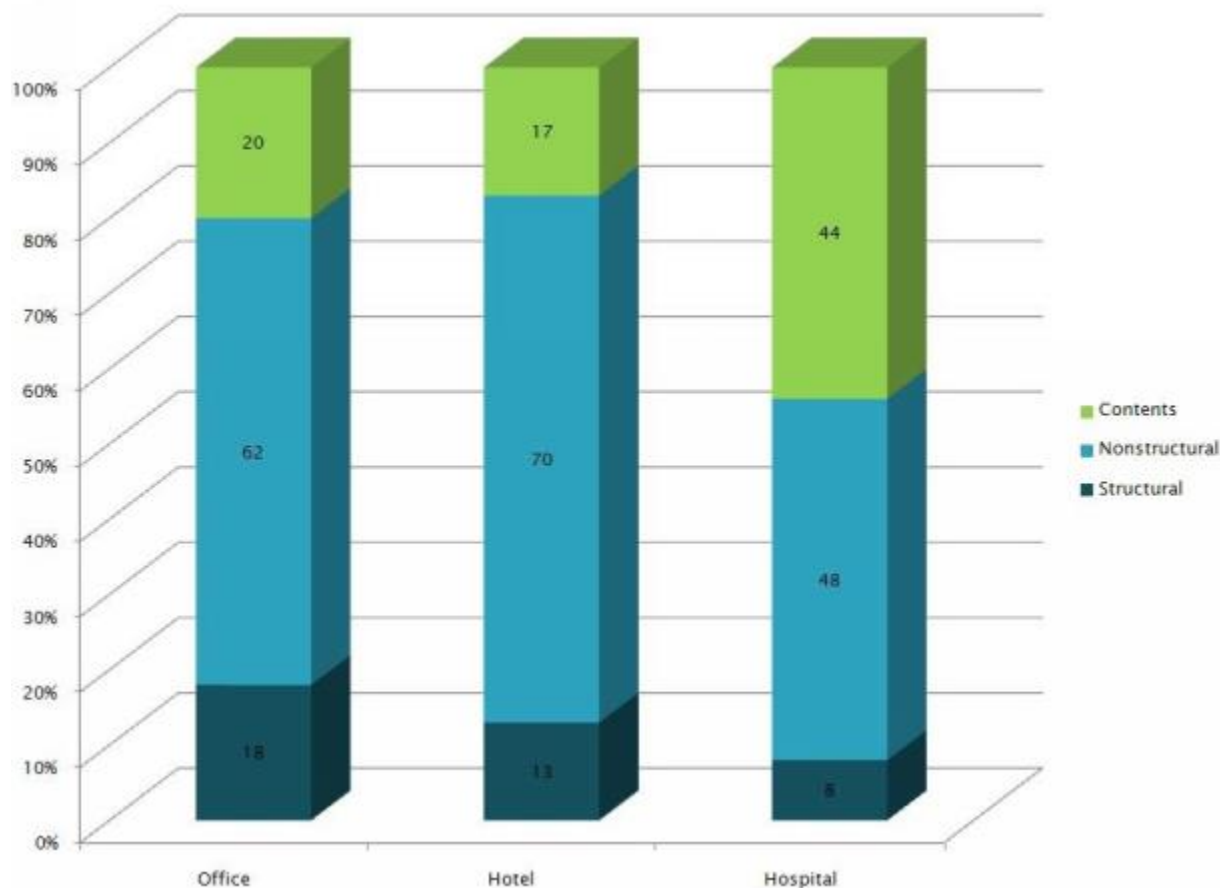


Figure 3.1.5-2. Typical Construction Costs for Different Building Component (FEMA E-74, 2012).

Finally, the use of the structure and required level of building performance need to be taken into consideration. For example, essential facilities that are expected to have minimal structural

damage following the design earthquake must have nonstructural components that are designed to match the seismic performance level of the facility.

3.2 ASCE 41 Seismic Evaluation and Rehabilitation Procedures Overview

3.2.1 Seismic Screening and Evaluation

ASCE 41-17 provides a three-tiered seismic screening and evaluation procedure using performance-based criteria. The process for seismic evaluation is depicted in Figure 3.2.1-1. The evaluation process consists of the following three tiers: Screening Procedure (Tier 1), Deficiency-Based Evaluation Procedure (Tier 2), and Systematic Evaluation Procedure (Tier 3).

The Tier 1 seismic screening procedure was used in this study. The Tier 1 seismic screening checklists questions are designed to uncover the seismic safety flaws and weaknesses of a school building and are in the form of positive evaluation statements describing building characteristics that are essential if the failures observed in past earthquakes are to be avoided. Compliant Tier 1 seismic screening statements identify conditions that are acceptable and non-compliant Tier 1 seismic screening statements identify seismic safety issues or conditions in need of further evaluation.

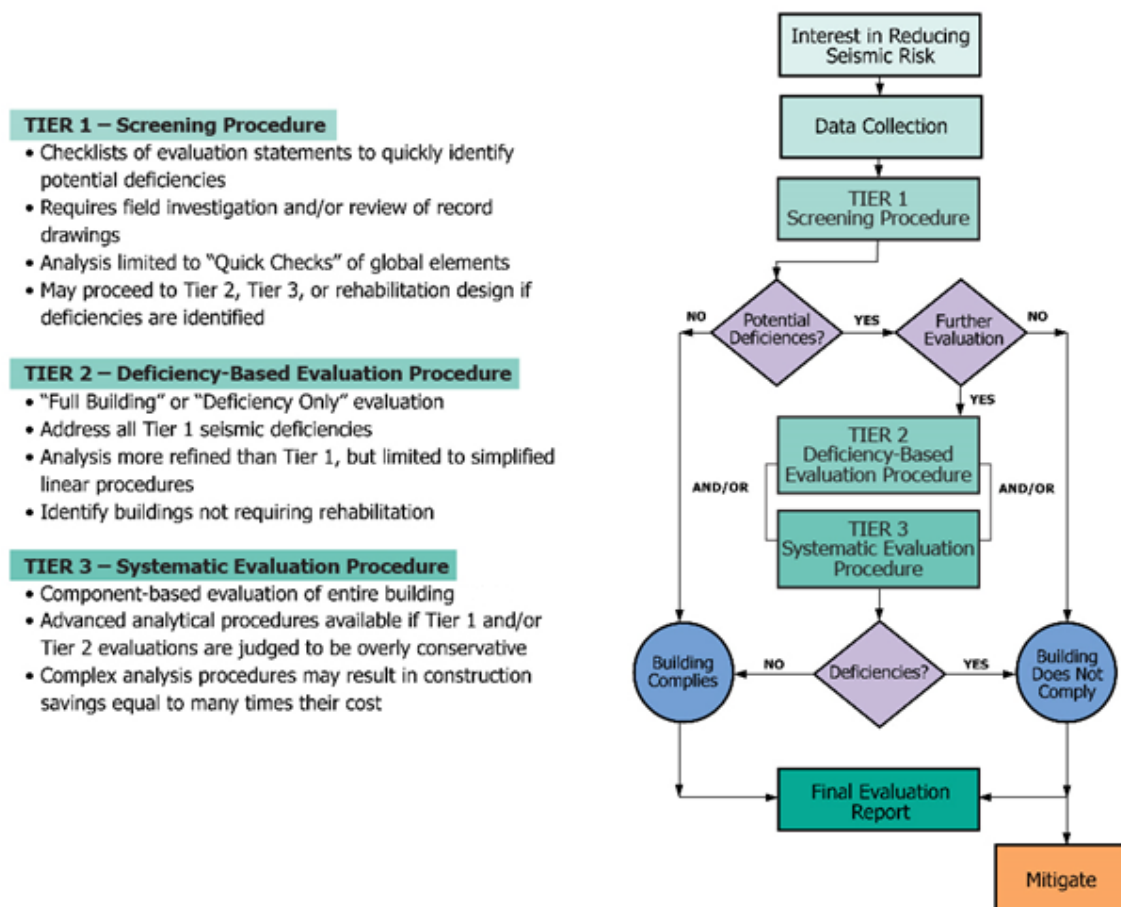


Figure 3.2.1-1. Flow Chart and Description of ASCE 41 Seismic Evaluation Procedures (ASCE 31, 2003).

3.2.2 Seismic Rehabilitation

If seismic deficiencies are identified in the evaluation process, the owner and design team should review all initial conditions before proceeding with the hazard mitigation. Many conditions may affect the retrofit design significantly, such as results of the seismic evaluation and seismic hazard study, building use and occupancy requirements, presence of hazardous materials, and other anticipated future building remodeling, modernization, or replacement. The basic process for performance-based seismic retrofit/upgrades design is illustrated in Figure 3.2.2-1.

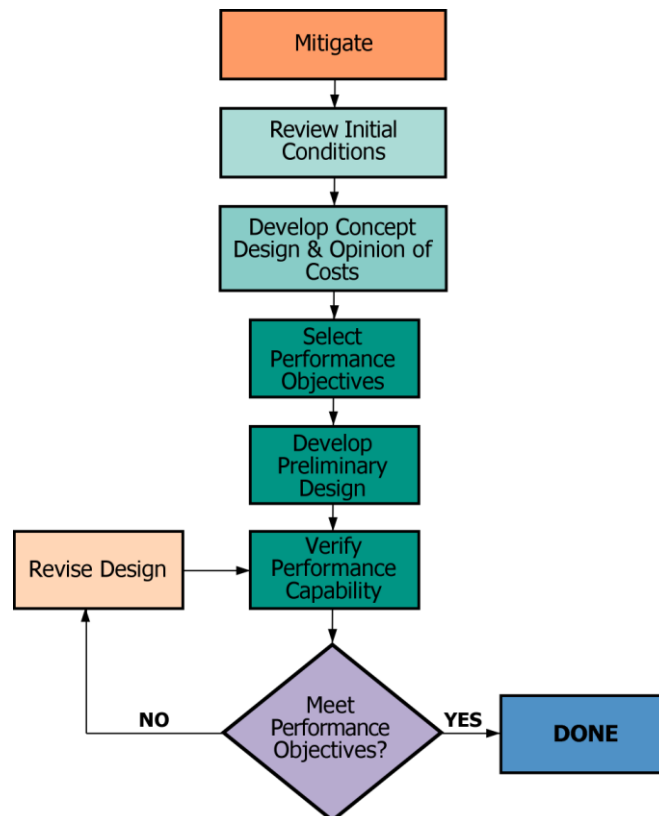


Figure 3.2.2-1. Seismic Rehabilitation Flow Diagram (ASCE 31, 2003).

Following the review of initial conditions, concept-level seismic retrofit/upgrade designs may be developed in order to determine rough opinions of probable construction costs for one or more seismic retrofit/upgrades performance objectives. This is the level of design and cost estimating work that has been performed for the 19 different buildings included in this statewide school seismic assessments study. The school district (owner) and their design team can then develop a seismic rehabilitation strategy considering the associated costs and feasibility. Schematic and final design can then proceed through an iterative process until verification of acceptable building performance is obtained.

3.3 FEMA 154 Rapid Visual Screening (RVS)

The standardized tool for performing rapid visual screening of buildings for seismic risks is the *FEMA 154: Rapid Visual Screening of Buildings for Potential Seismic Hazards* standard (Applied Technology Council, 2015). Based on extensive data and research on the seismic performance of buildings in previous earthquakes, these standards provide seismic screening criteria specific to each common building archetype, the structural system, configuration, and characteristics of the specific facility, and the seismic risk at each facility site.

This tool uses a scoring system to quantify the potential seismic vulnerability of a structure. A base score is identified based on modeled ground shaking. Other important factors are the buildings' lateral-force-resisting system (for example, wood or concrete shear walls, steel braced or moment frames, and masonry shear walls). This base score is then reduced according to the geological hazards (site class, landslide, and liquefaction hazards) and inherent vulnerabilities in the building's configuration (such as vertical and horizontal irregularities). The building score is also adjusted based on the construction year relative to benchmark years in which seismic design code requirements changed significantly.

Scores typically vary between 0.3 and 6.0. Lower scores indicate more-hazardous buildings and higher scores indicate buildings that have less risk. There is no official cutoff score that identifies which buildings should receive further evaluation, but, generally, a score of 2.0 or less is used to identify buildings that require further evaluation.

3.4 Washington State School Earthquake Performance Assessment Tool (EPAT)

The Washington State School Earthquake Performance Assessment Tool (EPAT) is a spreadsheet tool developed for the state of Washington by the Earthquake Engineering Research Institute (EERI). The spreadsheet uses FEMA Hazus fragility curves to calculate expected earthquake performance of schools based on basic school seismic screening characteristics. Hazus is a natural hazards loss estimation tool initially developed by FEMA in the 1990s. Hazus uses basic building information, construction type fragility functions, and expected ground shaking intensity to estimate the probable losses of buildings from a design-level earthquake. These results are displayed as a percentage of the building elements that are expected to be damaged in this earthquake. The EPAT spreadsheet only returns performance values for the building's structural systems, but nonstructural systems are likely to also sustain significant damage in a large earthquake.

3.5 Earthquake Performance Rating System Translation of ASCE 41 Tier 1 Checklists

A lesson learned from the Phase 1 study is the need to simplify the ASCE 41 Tier 1 checklists for each assessed building to better communicate to people without an engineering background the most important structural seismic deficiencies that need to be mitigated or further investigated. The Phase 2 study attempts to do this by providing both an engineering-based risk rating (described in this section) that characterizes the seismic safety risk of the building in each screening report, and then combining these ratings with other engineering and geologic hazard

information to determine prioritization of buildings studied (discussed in the Results section Prioritized Rankings of Phase 1 and 2 School Buildings by Relative Risk).

The project team used the ‘Earthquake Performance Rating System (EPRS) ASCE 41-13 Translation Procedure’ developed by the Structural Engineers Association of Northern California (SEAONC) (SEAONC, 2017) and the ‘Earthquake Performance Rating System User’s Guide’ (SEAONC, 2015) to determine a structural safety risk rating to prioritize the seismic evaluation items that need to be addressed. The EPRS procedure and user’s guide was published by the Existing Buildings Committee of SEAONC and its methodology has been adopted by the US Resiliency Council (USRC, <https://www.usrc.org>) in determining their building earthquake ratings. The EPRS includes guidelines that translate the ASCE 41 Tier 1 seismic evaluation structural checklists into star-ratings that address three focus areas of seismic performance: Safety, Repair Cost, and Recovery. Each of the focus areas has three sub-ratings: Structural, Geologic, and Nonstructural. However, based on the information gathered by the project team in both phases of this study, only a preliminary Structural Safety sub-rating could be determined for each building assessed. Although preliminary, the Structural Safety sub-rating will be helpful in informing school districts of the seismic risks and needs of their buildings, especially when accompanied by a list of seismic evaluation checklist items that can improve the Structural Safety sub-rating if mitigated.

The definitions of the Structural Safety sub-ratings used in this study are based on definitions used in the EPRS User’s Guide and by the USRC and have been adapted for use in this study. The EPRS is a five-star rating system, with one star being the lowest, or worst-performing building, and five stars being the highest, or best-performing building. The ratings are communicated in each of the seismic screening reports for each school building assessed in Phase 1 and 2 as follows:

- ★ **Risk of collapse in multiple or widespread locations**—Expected performance as a whole would lead to multiple or widespread conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.
- ★★ **Risk of collapse in isolated locations**—Expected performance in certain locations within or adjacent to the building would lead to conditions known to be associated with earthquake-related collapse resulting in injury, entrapment, or death.
- ★★★ **Loss of life unlikely**—Expected performance results in conditions that are unlikely to cause severe structural damage and loss of life. A three-star rating meets the Tier 1 Life Safety (LS) structural performance objective.
- ★★★★ **Serious injuries unlikely**—Expected performance results in conditions that are associated with limited structural damage and are unlikely to cause serious injuries.
- ★★★★★ **Injuries and entrapment unlikely**—Expected performance results in conditions that are associated with minimal structural damage and are unlikely to cause injuries or keep people from exiting the building. A five-star rating meets the Tier 1 Immediate Occupancy (IO) structural performance objective.

The checklist translation tables of the EPRS procedure are specific to each classified building type. See Figure 3.5-1 as an example.

Table 2.1 - RM1 (Reinforced Masonry Bearing Walls - Flexible Diaphragms)

Seismicity	System	Item	Perf. Level	C = Compliance Required for Safety sub-Rating:			
				5-Star	4-Star	3-Star	2-Star
Very Low Seismicity	Structural Components	LOAD PATH	LS	C	C	C	
Very Low Seismicity	Structural Components	WALL ANCHORAGE	LS	C	C	C	
Low Seismicity	Building System General	LOAD PATH	LS	C	C	C	C
Low Seismicity	Building System General	ADJACENT BUILDINGS	LS	C	C	C	
Low Seismicity	Building System General	MEZZANINES	LS	C	C	C	
Low Seismicity	Building Configuration	WEAK STORY	LS	C	C	C	C
Low Seismicity	Building Configuration	SOFT STORY	LS	C	C	C	C
Low Seismicity	Building Configuration	VERTICAL IRREGULARITIES	LS	C	C	C	C
Low Seismicity	Building Configuration	GEOMETRY	LS	C	C	C	C
Low Seismicity	Building Configuration	MASS	LS	C	C	C	C
Low Seismicity	Building Configuration	TORSION	LS	C	C	C	
Moderate Seismicity	Geologic Site Hazards	LIQUEFACTION	LS	C	C	C	
Moderate Seismicity	Geologic Site Hazards	SLOPE FAILURE	LS	C	C	C	C
Moderate Seismicity	Geologic Site Hazards	SURFACE FAULT RUPTURE	LS	C	C	C	C
High Seismicity	Foundation Configuration	OVERTURNING	LS	C	C	C	
High Seismicity	Foundation Configuration	TIES BETWEEN FOUNDATION ELEMENTS	LS	C	C	C	
Low and Moderate Seismicity	Seismic-Force-Resisting	REDUNDANCY	LS	C	C	C	
Low and Moderate Seismicity	Seismic-Force-Resisting	SHEAR STRESS CHECK	LS	C	C	C	C
Low and Moderate Seismicity	Seismic-Force-Resisting	REINFORCING STEEL	LS	C	C	C	
Low and Moderate Seismicity	Connections	WALL ANCHORAGE	LS	C	C	C	C
Low and Moderate Seismicity	Connections	WOOD LEDGERS	LS	C	C	C	C
Low and Moderate Seismicity	Connections	TRANSFER TO SHEAR WALLS	LS	C	C	C	C
Low and Moderate Seismicity	Connections	FOUNDATION DOWELS	LS	C	C	C	C
Low and Moderate Seismicity	Connections	GIRDER-COLUMN CONNECTION	LS	C	C	C	C
High Seismicity	Stiff Diaphragms	OPENINGS AT SHEAR WALLS	LS	C	C	C	
High Seismicity	Stiff Diaphragms	OPENINGS AT EXTERIOR MASONRY SHEAR WALLS	LS	C	C	C	
High Seismicity	Flexible Diaphragms	CROSS TIES	LS	C	C	C	C
High Seismicity	Flexible Diaphragms	OPENINGS AT SHEAR WALLS	LS	C	C	C	
High Seismicity	Flexible Diaphragms	OPENINGS AT EXTERIOR MASONRY SHEAR WALLS	LS	C	C	C	
High Seismicity	Flexible Diaphragms	STRAIGHT SHEATHING	LS	C	C	C	C
High Seismicity	Flexible Diaphragms	SPANS	LS	C	C	C	C
High Seismicity	Flexible Diaphragms	DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS	LS	C	C	C	C
High Seismicity	Flexible Diaphragms	OTHER DIAPHRAGMS	LS	C	C	C	C
High Seismicity	Connections	STIFFNESS OF WALL ANCHORS	LS	C	C	C	
Very Low Seismicity	Connections	TRANSFER TO SHEAR WALLS	IO	C			
Very Low Seismicity	Connections	FOUNDATION DOWELS	IO	C			
Very Low Seismicity	Foundation System	DEEP FOUNDATIONS	IO	C	C		
Very Low Seismicity	Foundation System	SLOPING SITES	IO	C	C		
Low, Moderate, and High Seismicity	Seismic-Force-Resisting	REINFORCING AT WALL OPENINGS	IO	C			
Low, Moderate, and High Seismicity	Seismic-Force-Resisting	PROPORTIONS	IO	C	C		
Low, Moderate, and High Seismicity	Diaphragms (Stiff or Flexible)	OPENINGS AT SHEAR WALLS	IO	C			
Low, Moderate, and High Seismicity	Diaphragms (Stiff or Flexible)	OPENINGS AT EXTERIOR MASONRY SHEAR WALLS	IO	C			
Low, Moderate, and High Seismicity	Diaphragms (Stiff or Flexible)	PLAN IRREGULARITIES	IO	C			
Low, Moderate, and High Seismicity	Diaphragms (Stiff or Flexible)	DIAPHRAGM REINFORCEMENT AT OPENINGS	IO	C			
Low, Moderate, and High Seismicity	Flexible Diaphragms	STRAIGHT SHEATHING	IO	C			
Low, Moderate, and High Seismicity	Flexible Diaphragms	SPANS	IO	C			
Low, Moderate, and High Seismicity	Flexible Diaphragms	DIAGONALLY SHEATHED AND UNBLOCKED DIAPHRAGMS	IO	C			
Low, Moderate, and High Seismicity	Flexible Diaphragms	NONCONCRETE FILLED DIAPHRAGMS	IO	C			

Figure 3.5-1. EPRS Translation for Reinforced Masonry Buildings (SEAONC, 2017)

The checklist translation tables prioritize the Tier 1 screening evaluation statements such that the more seismically critical evaluation statements all need to have a Compliant assessment by the assessing structural engineer to then be considered a 2-Star risk rating. The assessing engineer then moves on to the remaining evaluation statements of the Tier 1 checklist. If the structural engineer determines the assessments to be Complaint for all remaining evaluation statements, then the building gets a 3-Star rating. On the contrary, if the engineer determines the assessment

for any of the more critical evaluation statements to be Noncompliant or Unknown, the building is then considered a 1-Star risk rating.

It is important to note that determining the final EPRS star-ratings of a building is intended to be an iterative process by the structural engineer doing the ASCE 41 Tier 1 seismic assessment and the EPRS risk rating translation. A preliminary risk rating is determined based upon the ASCE 41 Tier 1 evaluation assessments. If the structural engineer agrees that the resulting risk rating accurately characterizes their overall assessment of the building and their engineering judgement, then the risk rating can be finalized. If the structural engineer does not agree with the resulting risk rating, they can revisit the Noncompliant statements and use their engineering judgement to reassess the severity of the deficiencies, how widespread the deficiencies are throughout the building, and subsequently revise or keep the evaluation assessment accordingly. The structural engineer and building owner may also choose to use the ASCE 41 Tier 2 analysis procedure to perform a more refined analysis of the Noncompliant Tier 1 evaluation statement to confirm whether the evaluation item is still seismically deficient.

For evaluation statements assessed as Unknown (U) due to lack of existing drawings or no access to visually observe the structure, the structural engineer and building owner may also choose to perform additional field observations to investigate the Unknown assessments. This may require selective demolition of architectural and fire protective finishes in representative areas, scanning of concrete or masonry walls for reinforcing, masonry in-plane shear tests, or removal of existing roofing in isolated areas. See Figure 3.5-2 for a flow chart of the EPRS process.

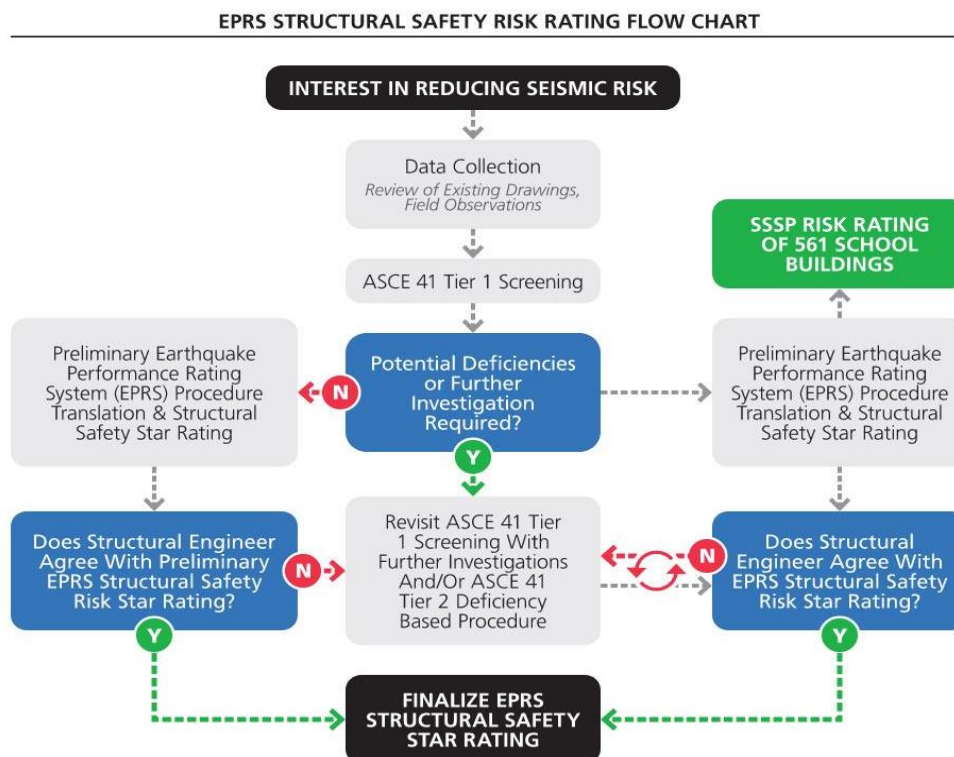


Figure 3.5-2. EPRS Flowchart Process.

In addition to the Structural Safety sub-rating, the EPRS procedure also includes safety sub-ratings for geologic site conditions and nonstructural systems. The results of the Structural, Geologic, and Nonstructural safety sub-ratings are then used to determine the Repair and Recovery risk ratings. Risk ratings and sub-ratings beyond the Structural Safety sub-rating are beyond the scope of this study. Furthermore, the Structural Safety sub-ratings determined for this study are preliminary ratings based on the information available for this study and a first and only iteration through the ASCE 41 Tier 1 checklists.

The preliminary ratings determined will often be conservative until more field investigation, structural analysis, and engineering judgment is performed by a structural engineer. The intent in providing a preliminary Structural Safety sub-rating is to provide school districts with a starting point of how seismically vulnerable the assessed buildings are based on the ASCE 41 Tier 1 assessments done for this study. These ratings, along with an itemized list of seismic deficiencies that can be mitigated or further investigated to achieve a higher star rating, should assist stakeholders in prioritizing the seismic needs for the school buildings assessed.

3.6 Seismic Screening and Evaluation Criteria

The following information was used by the project team in the field assessment and seismic evaluations as default criteria to help maintain consistency of the technical work.

3.6.1 Seismic Hazard Level

The following seismic hazard levels used in the study conform to ASCE 41-17.

Risk Category ^a	III
Structural Performance Objective ^b Performance	Limited Safety (LTD-S) Structural Level at BSE-2E Seismic Hazard Level.
Nonstructural Performance Objective ^c Level	Life Safety (LS) Nonstructural Performance at BSE-1E Seismic Hazard Level.
Site Class ^d	Based on Site Class provided by site-specific Vs30 measurements determined by DNR-WGS as part of this study.

Notes:

- a. All the school buildings are evaluated as Risk Category III structures as defined by ASCE 7-16 Section 1.5. Generally, schools with more than 250 occupants are classified as Risk Category III, and schools with less than 250 occupants are classified as Risk Category II. While it is possible that some school buildings may technically be classified as Risk Category II based on their current occupancy (quantity of occupants), we elected to evaluate all structures as Risk Category III structures for the following reasons:
 1. This is the same approach that was taken for Phase 1 of the project.
 2. This study evaluates a small sample of the entire number of the school buildings in Washington State. The total quantity of school buildings in Washington State is approximately 4,476; 339 buildings are included for evaluation in this study. Using the same Risk Category to evaluate all structures means that the results can be extrapolated, where appropriate, to other structures not included in this study.
 3. Using a consistent Risk Category for all buildings means that the same criteria is used for all buildings and allows for consistent comparisons between buildings of the same construction type and across buildings of different construction types regardless of the number of occupants.
- b. The Structural Performance Objective is Limited Safety (LTD-S) at the BSE-2E Seismic Hazard Level according to Table 2-2 of ASCE 41-17, with footnote c stating, "For Risk Category III, the Tier 1 screening checklists shall be based on the Collapse Prevention Performance Level (S-5), except that checklist statements using the Quick Check procedures of Section 4.4.3 shall be based on M_s factors taken as the average of the values for Life Safety and Collapse Prevention." The BSE-2E Seismic Hazard Level makes use of a probabilistic earthquake event with a probability of exceedance of 5% in 50 years or a return period of 975 years.
- c. The Nonstructural Performance Objective was selected as Life Safety (LS) at the BSE-1E Seismic Hazard Level. This performance level was selected in lieu of Position Retention (PR) for the following reasons:
 1. This performance level is intended to allow building occupants to exit the building after an earthquake while minimizing the risk of fatalities. It is generally accepted as the minimum standard for buildings of any type.
 2. The amount of time and budget allotted for this project does not allow for a more-detailed evaluation of nonstructural systems required when evaluating to Position Retention.
- d. Initially, the ICOS database site classifications were used to conduct the seismic evaluations until the DNR-WGS fieldwork concluded. Once DNR-WGS's fieldwork was concluded, the site classifications were updated based on the information provided by DNR-WGS, and these revised values were used for the seismic evaluation.

3.7 Fire Stations Studied

In Phase 1 of this study, five fire stations located within a mile of a public school were seismically screened to an Immediate Occupancy structural performance objective. In Phase 2, two more fire stations within a mile of a public school were similarly assessed. See 3.7-1 for Phase 1 and 2 fire station locations. The selection criteria for these two Phase 2 fire stations were based on seismic hazard, availability of existing drawings, tsunami risk, and construction type. In Phase 2, these two fire stations also received a conceptual seismic upgrade design report and cost estimate to determine possible upgrade solutions and probable cost to seismically upgrade these buildings to meet an Immediate Occupancy structural performance objective. Figure 3.7-1 shows a map of the assessed fire stations.

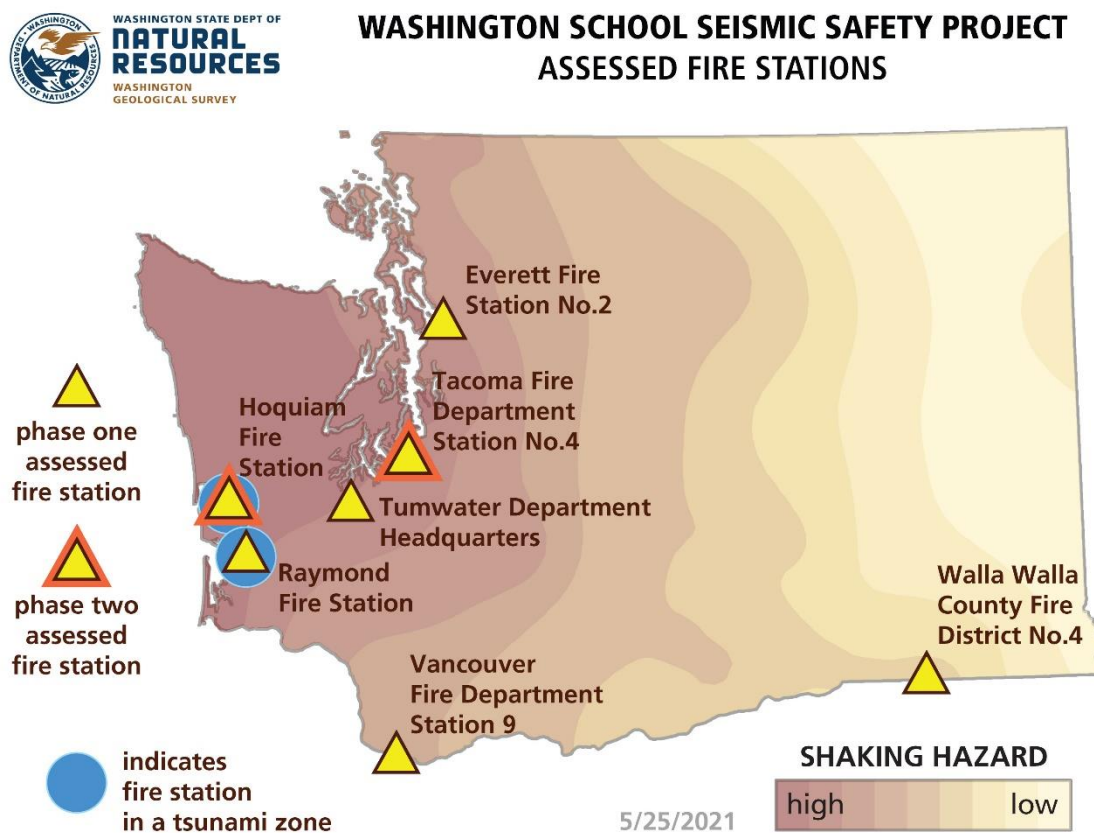


Figure 3.7-1. Map of Assessed Phase 1 & Phase 2 Fire Stations (DNR, 2021).

4.0 Seismic Screening Findings

4.1 Finding Summary and Database-Wide Trends

4.1.1 ASCE 41 Tier 1 Structural Findings Summary

The ASCE 41 Tier 1 structural evaluation results show that many buildings have items that are identified as seismic vulnerabilities. In general, older buildings are known to possess more seismic vulnerabilities than newer buildings. Older buildings were generally designed for lower levels of seismic force and with less interconnectedness than new buildings. Prior to the first Uniform Building Code in 1927, no seismic considerations were used in the design of buildings. URM buildings and nonductile concrete buildings are shown to categorically possess the highest percentages of noncompliant structural evaluation items. These results confirm that the evaluated school buildings included in this study possess seismic vulnerabilities that are in line with the expert's expectations that led to the formation of this study.

Figure 4.1.1-1 is a chart of the total number of permanent, public K-12 Washington school buildings (grey) categorized by decade built (or the date there was a last major seismic upgrade) and material type. This information is based on the OSPI's Information and Condition of Schools (ICOS) database. Figure 4.1.1-2 is a similar chart only of the schools assessed in this report and their construction type (wood, concrete, etc.) are color coded.

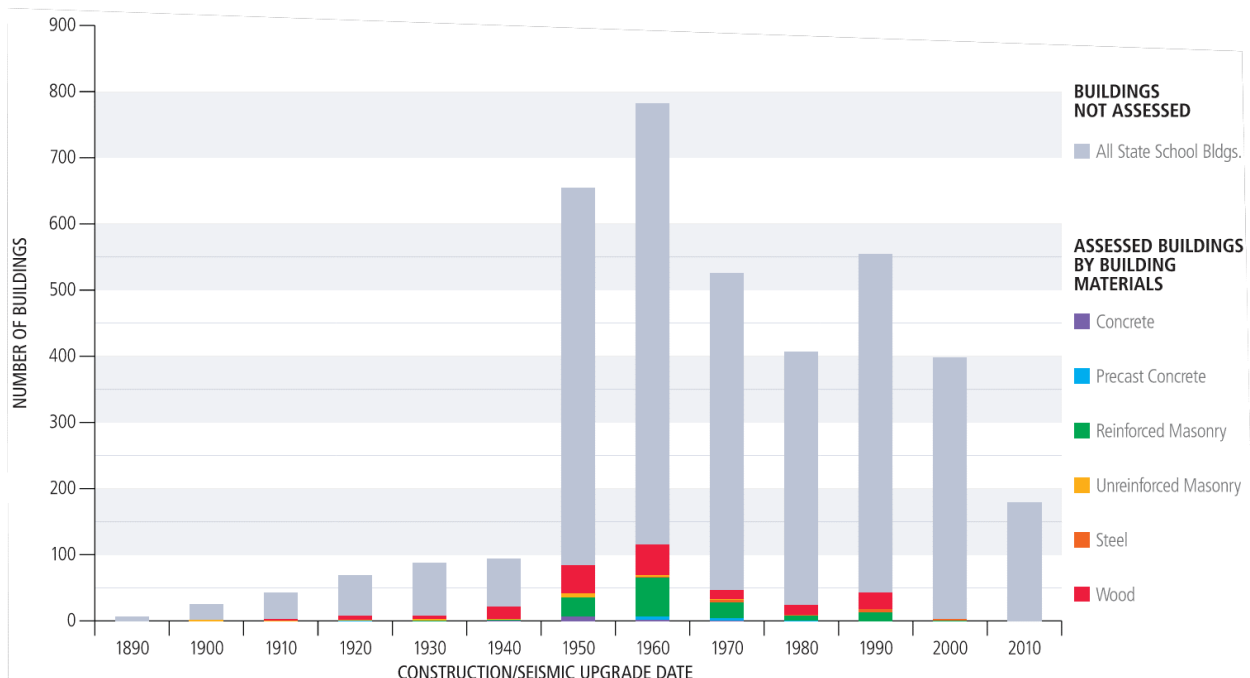


Figure 4.1.1-1. Distribution by Decade Built & Primary Construction Type of Buildings Assessed Compared to Overall Numbers of School Buildings Statewide.

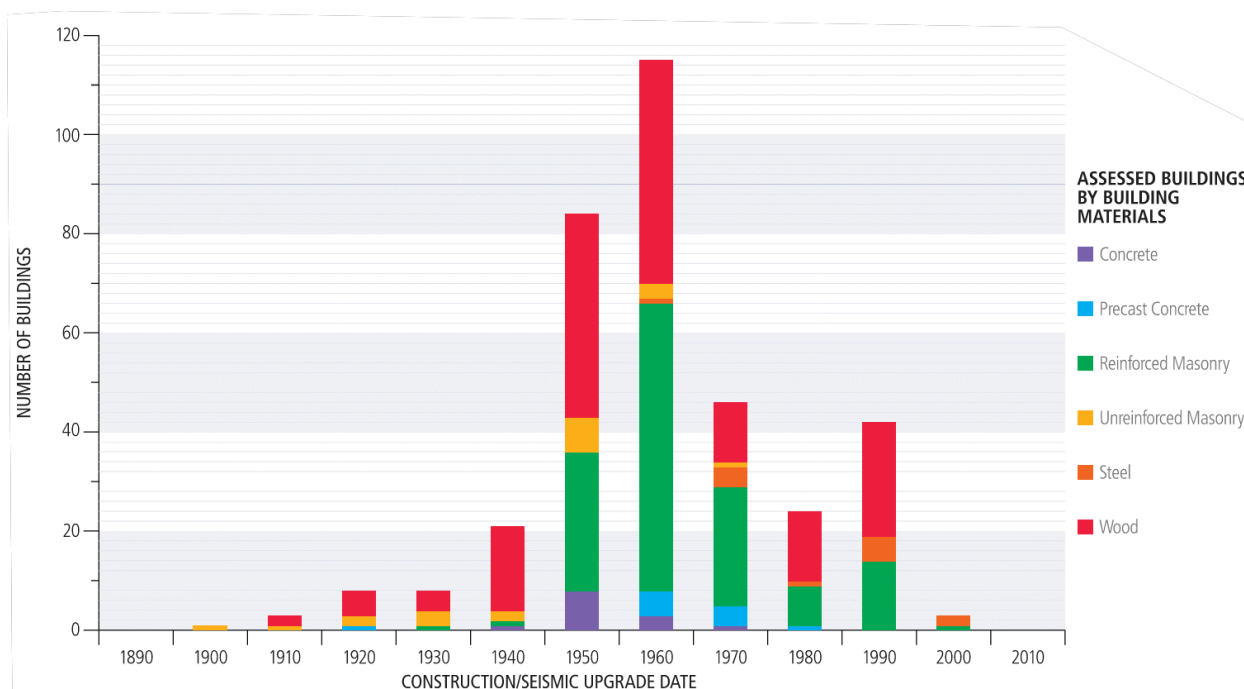


Figure 4.1.1-2. Distribution by Decade Built & Primary Construction Type of Buildings Assessed.

4.1.2 EPAT Summary

The Washington School Earthquake Performance Assessment Tool (EPAT) is a spreadsheet tool developed for the state of Washington that calculates expected earthquake performance of schools, based on basic school characteristics, using FEMA Hazus fragility curves. FEMA Hazus is a standardized natural hazards loss estimation tool initially developed by FEMA in the 1990s. Hazus uses basic building information and construction type fragility functions to estimate the probable losses of buildings from an earthquake. The loss estimates are probabilistic, meaning that the single-value estimates only represent the median expected outcome; the range of probabilities of the outcomes is not represented.

Table 4.1.2-1 shows the EPAT median, average, maximum, and minimum results for all 339 buildings included in the study. The information displayed in the table is based on each building's existing configuration and estimations of loss, life safety risk level, and post-earthquake tagging as expected for the ASCE 7 design earthquake.

WHAT IS THE DIFFERENCE BETWEEN MEDIAN AND AVERAGE?

The **Median** value is the value that separates the higher half of values from the lower half of values within a data set.

The **Average** value is the arithmetic mean where the values of each item in the data set are added together and then divided by the number of items.

Table 4.1.2-1. Washington State Schools EPAT Summary Results (339 School Buildings).

Calculated Value	Median	Average	Maximum	Minimum
Building Damage Estimate Ratio (Amount of Building that is Damaged)	56%	54%	91%	7%
Probability Building is Not Repairable	52%	51%	93%	5%
Life Safety Risk Level	High	-	Very High	Very Low
Most Likely Post-Earthquake Tagging	Red*	-	Red*	Green*

*Red = Unsafe to Occupy, Yellow = Restricted Building Access, Green = No Restrictions on Building Access

The EPAT summary results in Table 4.1.2-1 show that the median building is expected to have more than half of its building elements damaged, and it is expected that almost a half of the buildings included in the study will not be repairable, meaning these buildings will likely need to be demolished. The most likely post-earthquake tagging identified by EPAT is “Red”, meaning the majority of school buildings included in the study are expected to not be safe to occupy following the design earthquake event.

4.2 ASCE 41 Tier 1 Seismic Screening Findings

ASCE 41 Tier 1 seismic screening evaluations were conducted on the 339 school buildings included in the study. This section describes the findings and trends associated with these seismic screening evaluations. The ASCE 41 Tier 1 seismic screening process is conducted by reviewing generalized building seismic screening checklist statements from ASCE 41 and determining whether a building structural element complies with that particular seismic screening statement or is noncompliant with that particular seismic screening statement.

Original building structural drawings were available for review for about 63 percent of the buildings studied, 20 percent of buildings had partial or incomplete drawings available for review, and 17 percent had no available record drawings for review. Where existing building drawings or other information was not available for review, the engineering data gathering was limited to visual observations by the project team of licensed structural engineers. Where building component compliance or noncompliance was unknown due to lack of available information, the unknown conditions were indicated on the ASCE 41-17 Tier 1 seismic screening checklists.

This section describes the results of the ASCE 41 Tier 1 seismic screening findings and trends by displaying the Tier 1 information that is “noncompliant” and “noncompliant or unknown”. This way, the information displayed reflects both the seismic structural vulnerabilities and the uncertainty associated with the data gathering.

In many cases, based on the vintage and the structural system of a building, it is suspected that a certain portion of “unknown” items would be seismically “noncompliant” based on the Tier 1

screening checklists if more detailed information were available for review. It is logical to evaluate building vulnerability and risk based on the multiple factors.

4.2.1 Data and Statistics for All School Building Types

Figure 4.2.1-1 shows the construction types of the buildings included in the study.

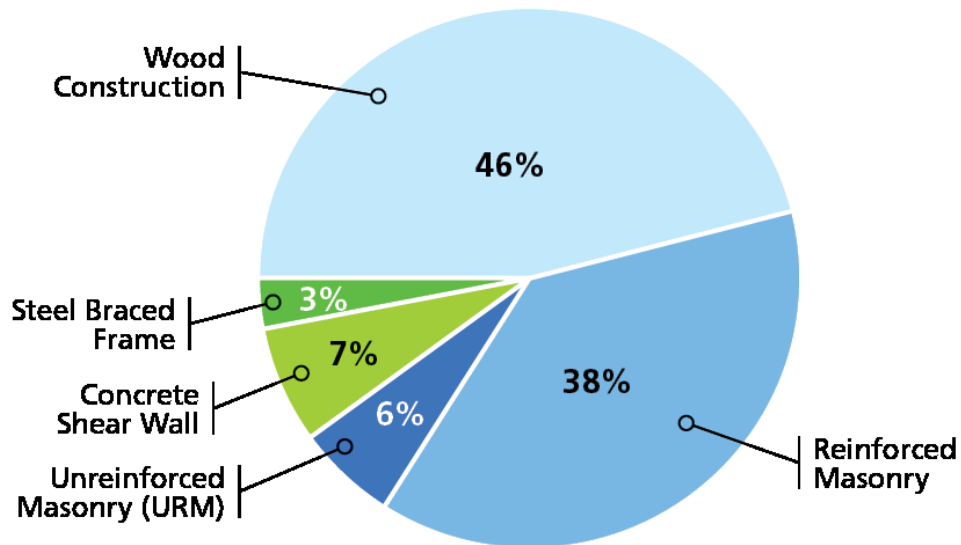


Figure 4.2.1-1. Distribution of School Building Construction Types Investigated within this Study.

Table 4.2.1-1 shows statistics about the buildings included in the study.

Table 4.2.1-1. ASCE 41 Tier 1 School Building Statistics (339 School Buildings).

Parameter	Value	Notes
Average Year of Construction	1967	Washington State has many older school buildings built in the early 20 th Century, with significant amounts of construction occurring all the way into the 21 st Century. A significant percentage of Washington State school buildings were built in the 1950s and 1960s, resulting in this average year of construction.
Median Year of Construction	1968	The average and median year of construction are the same, indicating that the selected buildings are not heavily weighted in one direction around the median.
Average Square Footage	28,472	The average square footage exceeds the median square footage, meaning there are a smaller number of buildings included in the study with very large square footages that skew the average higher.
Median Square Footage	17,364	The median square footage is smaller than the average square footage, meaning that, while there are some buildings that are very large (largest is over 200,000 square feet), the majority of buildings possess square footage values less than this number.

4.2.2 ASCE 41 Tier 1 Seismic Screening Data Analyses Trends

The results of the ASCE 41 Tier 1 evaluations were analyzed for trends that may indicate characteristic hazards and similarities and differences between buildings of different vintages and with different features.

Figure 4.2.7-1 shows the percent noncompliant items that each building possesses, categorized by building type. The horizontal axis is plotted by construction or seismic upgrade date. The vertical axis displays the percent noncompliant items. The percent of noncompliant items for each building was determined by dividing the quantity of noncompliant items for each building by the total possible quantity of evaluation statements.

The figure shows that buildings built in the 1950s through the 1970s tend to have a slightly higher percentage of noncompliant items than buildings built in the 1980s through the 2000s. Buildings built before the 1950s tend to have smaller amounts of noncompliant items partly because these older buildings tend to have more unknown items. No single building has more than 50 percent noncompliant items. Several buildings have zero noncompliant items; however, in many instances this may be related to the lack of available information with which to complete the evaluation. These buildings may have evaluation items that are classified as “unknown”.

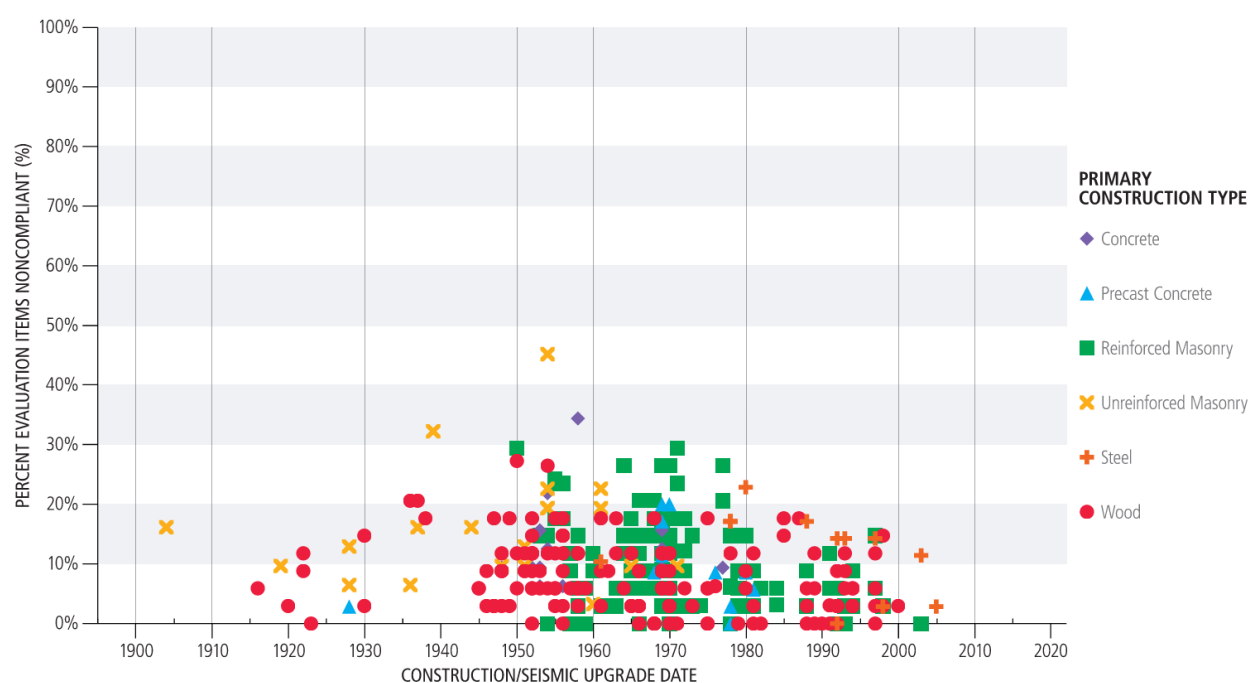


Figure 4.2.7-1. Percent ASCE 41 Tier 1 Items Noncompliant by Building Construction Type. (Appendix Figure B.1-1)

The previous figure only shows the percent of items identified as noncompliant. It does not show items that are classified as unknown. Figure 4.2.7-2 shows the percent of items classified as either noncompliant or unknown. The horizontal axis is plotted by construction or seismic upgrade date. The vertical axis displays the percent of noncompliant or unknown items. The percent of noncompliant or unknown items for each building was determined by dividing the

total quantity of noncompliant or unknown items for each building by the total possible quantity of evaluation statements.

Older buildings within each construction type tend to have higher percentages of seismically noncompliant or unknown items. Although, there is significant variability in the percentages of noncompliant and unknown items. There are many buildings built in the 1970s and 1980s that have higher percentages of noncompliant and unknown items compared to certain buildings built in the 1950s and 1960s. One URM building possesses a noncompliant or unknown percentage of about 70 percent. There is no discernable trend with URM buildings where buildings do not appear to be better or worse depending on age. There is no building that has zero noncompliant or unknown evaluation items.

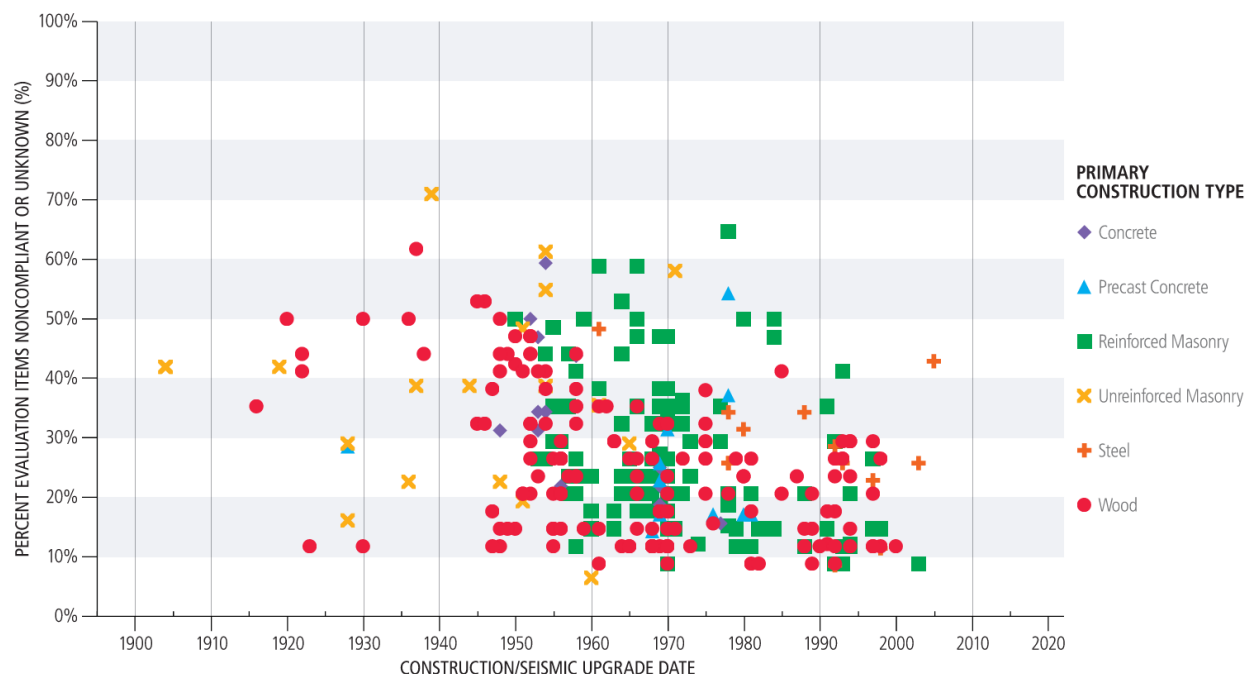


Figure 4.2.7-2. Percent ASCE 41 Tier 1 Items Identified as Noncompliant or Unknown Classified by Building Construction Type.
(Appendix Figure B.1-2)

4.3 EPAT Seismic Screening Findings and Data Analyses Trends

The primary value calculated for each building from EPAT is the amount of damage each existing building is expected to sustain in a design-level earthquake event. This value is displayed as a percentage of the building elements that are expected to be damaged. The design-level earthquake event is defined as being two-thirds of the magnitude of the maximum considered earthquake (MCE_R). The MCE_R is a risk-adjusted probabilistic event with a return period of 2,475 years. While not exact, the magnitude of the design-level earthquake event is similar to the magnitude of an earthquake event with a 475-year return period for many locations on the west coast of the United States. Earth scientists expect the average return period of a Cascadia Subduction Zone (CSZ) earthquake to be approximately 500 years. It is possible that a

CSZ earthquake could be approximately the magnitude of the design level earthquake for many parts of Washington State, depending on the particular earthquake characteristics.

Figure 4.3-1 shows the building damage estimate ratio in the design earthquake plotted against building construction or seismic upgrade date. The figure also includes different symbols for the building lateral system's primary construction material type.

The figure shows that school buildings built after 1975 have precipitously decreasing damage estimate ratios, with school buildings constructed in the 1990s and the 2000s generally possessing the lowest damage estimate ratios of all the school buildings evaluated. One significant factor in earthquake performance is the building code standard to which a building was originally designed. The EPAT spreadsheet separates Washington State into zones where the design standards at the time of construction were different. According to the EPAT documentation, historically the Puget Sound Region has had the strictest building code requirements. Buildings in the Puget Sound Region were also designed for the highest level of earthquake shaking due to the high seismicity of the region. Buildings in the rest of Washington State were historically designed to lower seismic force and detailing standards.

Starting in 1975, the state of Washington adopted a statewide building code for the first time. The adoption of a statewide standard made construction requirements uniform across the state. This adoption of the statewide standard, in addition to significant improvements in the building codes through the 1970s, 1980s, and 1990s, led to school buildings that are significantly more resilient to earthquakes compared to older school buildings. This is illustrated in the figure, with the decreasing damage estimate ratios for buildings built in the 1980s, 1990s, and 2000s.

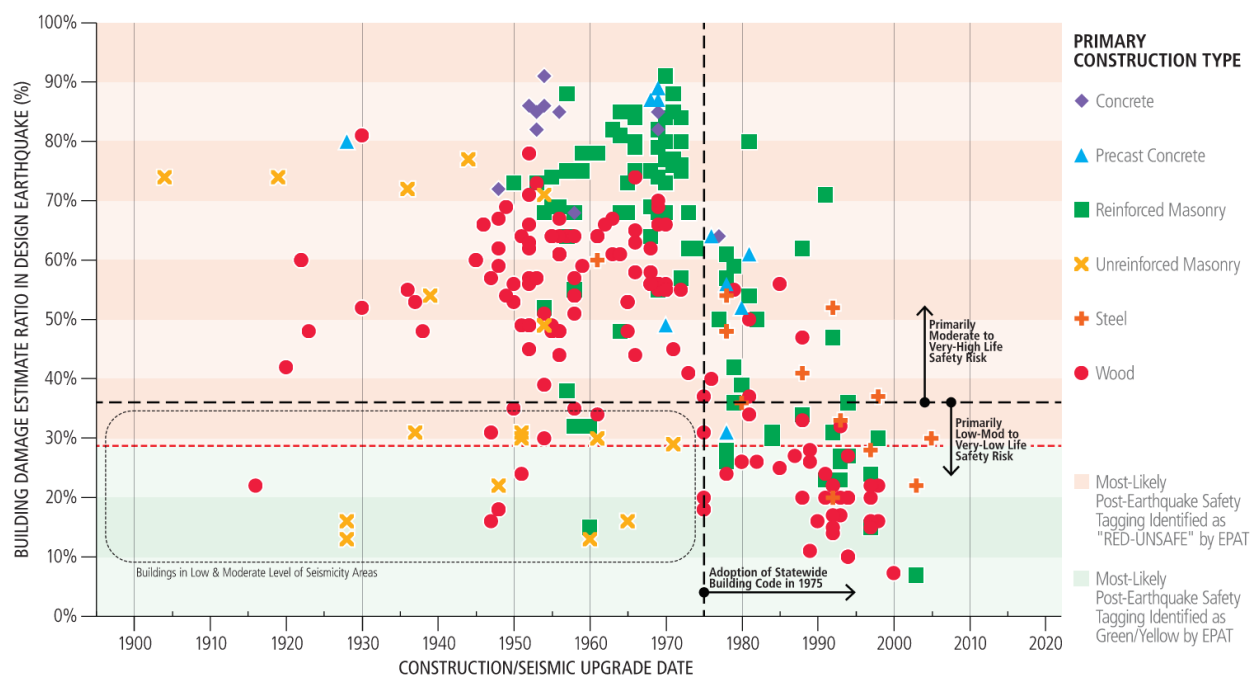


Figure 4.3-1. EPAT Damage Estimate Ratio Classified by Building Construction Type.
(Appendix Figure B.1-11)

Figure 4.3-2 shows a map of each school building and its EPAT building damage estimate ratio. Buildings located in western Washington tend to have higher damage estimate ratios than buildings in central and eastern Washington. However, building construction type and the quality of construction makes a significant difference, and there are some buildings in central and eastern Washington that are expected to experience higher amounts of damage.

Percentage Damage Estimate for School Buildings

Damage Estimate

- 75-100%
- 50-75%
- 25-50%
- 0-25%

SHAKING HAZARD
high
low

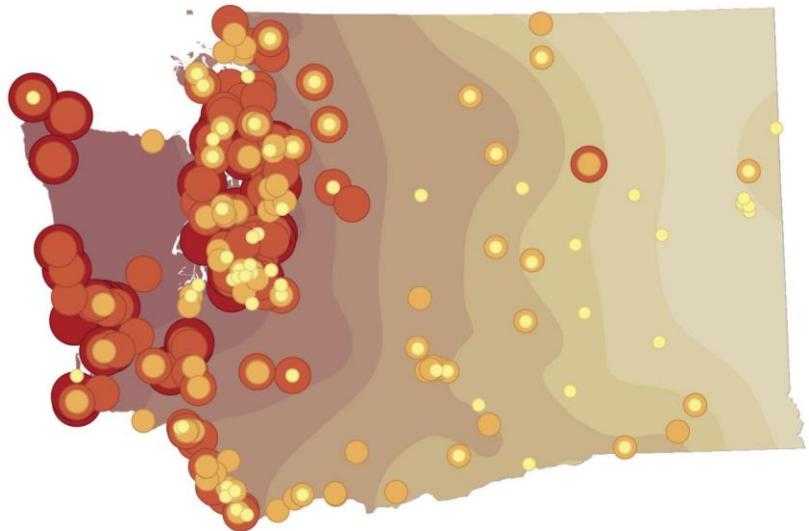


Figure 4.3-2. EPAT Damage Estimate Ratio Mapped Across the State (WA DNR, 2021).

4.4 FEMA 154 RVS Results

Table 4.4-1 shows the median, average, maximum, and minimum calculated FEMA 154 Rapid Visual Screening (RVS) scores for the Phase 2 schools. RVS is a method of assigning a score to a building based on a building's basic features (building type, building age, soil type, seismicity, and structural irregularities). The primary intent of the scoring is to identify potentially hazardous buildings that require further seismic evaluation. There is no official cutoff score, but generally a score of 2.0 or less is used to identify buildings that require further evaluation. Lower scores indicate more-hazardous buildings and higher scores indicate buildings that have less risk. Sixty-eight percent of the Phase 2 buildings possess an RVS score that is less-than-or-equal to 2.0, indicating that further evaluation work may be warranted to more accurately determine their seismic risk.

Table 4.4-1. Washington State Schools RVS Summary Results for Phase 2 Buildings.

RVS Result	Value
Median Score	1.7
Average Score	2.1
Max Score	5.5
Min	0.3

4.5 EPRS Structural Safety Sub-Ratings (Star-Ratings) Results

Preliminary structural safety sub-ratings for 561 school buildings assessed in both Phase 1 and Phase 2 were determined using the findings from the ASCE 41 Tier 1 seismic evaluation checklists. The EPRS is a five-star rating system, with one star being the lowest, or worst-performing buildings, and five stars being the highest, or best-performing buildings. Ninety-three percent of the 561 school buildings assessed have one-star Structural Safety sub-ratings based on the information available. Four percent of the school buildings assessed have two-star ratings and three percent of the school buildings have three-star ratings. Such a high percentage of one-star ratings was not surprising given that the criteria for selecting school buildings for this study was heavily weighted toward buildings that are older structures and lack the seismic durability and interconnection that more modern buildings have.

Most of the school buildings assessed in Phase 1 and Phase 2 are also not considered “post-benchmark” buildings. Post-benchmark buildings are those that are expected to possess equivalent earthquake performance to buildings designed to current code (post-benchmark buildings are typically those constructed in 1999 or later). In addition, many of the assessed buildings were also built before Washington State adopted its first statewide building code in 1975. The buildings assessed were selected in large part because of their older age and need for seismic evaluation. ASCE 41 infers that post-benchmark buildings, based on past observed earthquake damage, can be expected to provide Life Safety structural performance at a lower than current code seismic event. Consequently, it was not surprising that the vast majority of the assessed buildings would have a preliminary one-star structural safety sub-rating.

In addition, many buildings assessed did not have existing drawings or limited site observation to confirm critical seismically desirable attributes such as complete load paths, out-of-plane wall anchorage, interconnection of structural components, and diaphragm integrity. This resulted in many ASCE 41 Tier 1 seismic screening checklist items being evaluated as Unknown (U). To be consistent with the EPRS Translation Procedure, the preliminary Structural Safety sub-ratings for this study considered Unknown conditions as Noncompliant (NC). These Unknown conditions being considered as Noncompliant resulted in many Structural Safety sub-ratings of one star, and therefore these Structural Safety star ratings should not be used as an absolute condemnation of a building but instead as an indication that these buildings need further seismic investigation and analysis.

The overwhelming number of 1-star Structural Safety ratings further reinforces the need to voluntarily upgrade or replace older buildings in high seismicity areas. It is highly encouraged and recommended that school districts and structural engineers further study the ratings and assessments of their oldest and most vulnerable buildings and discuss how best to improve the seismic safety of their school facilities.

4.6 Prioritized Rankings of Phase 1 and Phase 2 Schools by Buildings Relative Risk

Phase 1 and 2 school buildings were ranked to prioritize buildings for seismic retrofit by relative risk. Engineering judgment was used to assign buildings to one of four categories: Very High Priority, High Priority, Moderate Priority, and Lower Priority. The prioritization of schools

compares buildings to one another by selected parameters using engineering judgment. The parameters for building comparison include: building construction date, construction type, level of site seismicity, extents of previous seismic upgrade work (if any), soil liquefaction potential, EPRS Structural Safety star rating, EPAT expected building damage, FEMA 154 RVS score, and an ASCE 41 Tier 1 checklist percent of “noncompliant” or “unknown”. A small adjustment was made for buildings of larger square footage to slightly prioritize larger buildings over smaller ones with the idea that more people may be at risk in buildings of larger area. Finally, the engineers who evaluated each building also used their judgment to adjust the building category, if they felt the scoring system did not accurately capture the building risk. See Appendix B.3 for a more-detailed description of the prioritized ranking scoring system used and the final prioritized lists.

Table 4.6-1 lists the prioritization categories, the category definition, and the types of buildings typically in each category. Figures 4.6-1 through 4.6-4 show the spatial distribution of these buildings and those that received concept-level design studies in Phases 1 and 2.

Table 4.6-1. Prioritized Building Ranking Categories Summary.

Prioritization Category	Category Definition	Typical Buildings in Category
Very High Priority	These buildings have the highest seismic risk and have a clear and strong need to receive seismic upgrades. The benefits of seismic performance and structural integrity gained by performing seismic upgrades are likely to significantly exceed the cost of the upgrades by a large margin.	Typically unreinforced masonry buildings and non-ductile concrete buildings built before the 1960s and located in high seismic zones. Some very high risk reinforced masonry buildings are also in this category.
High Priority	These buildings also have a strong need to receive seismic upgrades and would greatly benefit from voluntary seismic upgrades or seismic improvements that are incorporated with other systems upgrade projects or modernizations. The benefits of seismic performance and structural integrity gained by performing seismic upgrades likely exceed the cost of the upgrades.	Typically reinforced masonry and wood buildings built in the 1950s, 1960s, and 1970s and located in high seismic zones. Some unreinforced masonry buildings located in moderate and low seismic zones are also included in this category.
Moderate Priority	These buildings are not as high risk as the buildings in the High and Very High categories. Depending on level of seismicity, some buildings may or may not have a need to receive seismic upgrades. In areas of high seismicity, these buildings would still benefit from voluntary seismic upgrades that may be able to achieve seismic performance similar to modern buildings. However, the financial benefits of seismic upgrades may or may not exceed the costs.	Typically, buildings of various construction types built in the 1960s through the 1990s located in high, moderate, and low seismic zones.
Lower Priority	The benefits of seismic performance and structural integrity gained by performing seismic upgrades would likely not exceed the costs. Some buildings in this category already meet the Life Safety structural performance objective and were built to modern seismic standards where seismic upgrades would not be needed.	Typically buildings of various construction types built in the 1980s through the 2010s located in high, moderate, and low seismic zones.

The following are notes and caveats about the prioritized rankings.

1. The list of buildings only includes school buildings assessed in Phase 1 and Phase 2 of the Washington State School Seismic Safety Project. This represents approximately 12 percent of recognized school buildings in the ICOS database. Prioritization of the rest of the schools in Washington State requires further study and updates to the information in ICOS.
2. The main seismic evaluation portion of this study evaluated buildings using ASCE 41 Tier 1 procedures. In addition, many buildings had incomplete information, which required the assessment team to make notes where items were unknown. Tier 1 procedures are typically the first step taken in identifying building-specific seismic risks. However, Tier 1 evaluations must be followed up with ASCE 41 Tier 2 or Tier 3 evaluations prior to conducting seismic upgrades. In addition, the buildings have not been evaluated by architects, mechanical engineers, electrical engineers, fire protection engineers, or geotechnical engineers. Further assessments by a structural engineering and architectural/engineering team are required to further determine the extent of seismic upgrades and the building-specific benefits and costs of seismic upgrades.
3. Data used for prioritizing the school buildings assessed in this study were gathered from 2018–2021. Some school buildings listed are undergoing renovations or have subsequently been upgraded, modernized, or seismically improved voluntarily. These buildings should move down on the priority list once the seismic improvements are implemented and reviewed by a structural engineer.
4. Whether or not a building was located in a tsunami inundation zone was not used as a component of the development of the prioritized rankings. Buildings that are located in tsunami inundation zones may need to be further evaluated to determine the optimum course of action. In many cases, it may be more cost effective to relocate a school outside of a tsunami inundation zone than to upgrade the building. Alternatively, constructing purpose-built tsunami vertical evacuation structures or hardening evacuation routes may be a cost-effective way to improve the survivability of people located in tsunami inundation zones. In these cases, seismically upgrading buildings with the purpose of allowing people to evacuate and reach higher ground may be appropriate. Evaluation of tsunami hazards was outside the scope of this project. It may be appropriate to evaluate structural loads from tsunamis in future studies.
5. The table that lists the prioritized rankings categorizes buildings into one of four categories. Within each category, the school buildings are listed alphabetically. Alphabetization was chosen to provide some amount of organization to the table. The buildings in each category should be construed as possessing approximately equal risk to one another. That is, the buildings within each category are not further prioritized beyond each of the four categories.
6. Some buildings within the study have multiple additions constructed over multiple years. In addition, different portions of the same building may be constructed of multiple structural building types. Generally, the highest risk portion of each building was used to prioritize the buildings. It may be the case that only part of a building is the highest risk portion, with other portions of a building being less at-risk.

WASHINGTON SCHOOL SEISMIC SAFETY PROJECT VERY HIGH PRIORITY SCHOOLS

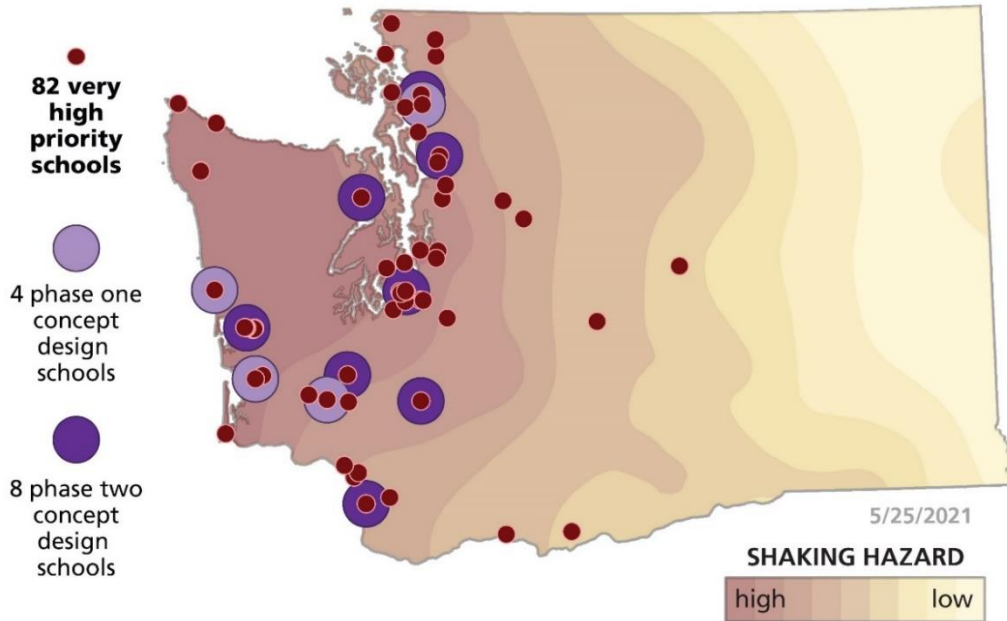


Figure 4.6-1. Map Showing Very High Priority Schools (dark red dots) and Very High Priority Phase 1 & 2 Concept Design Schools (WA DNR, 2021).

WASHINGTON SCHOOL SEISMIC SAFETY PROJECT HIGH PRIORITY SCHOOLS

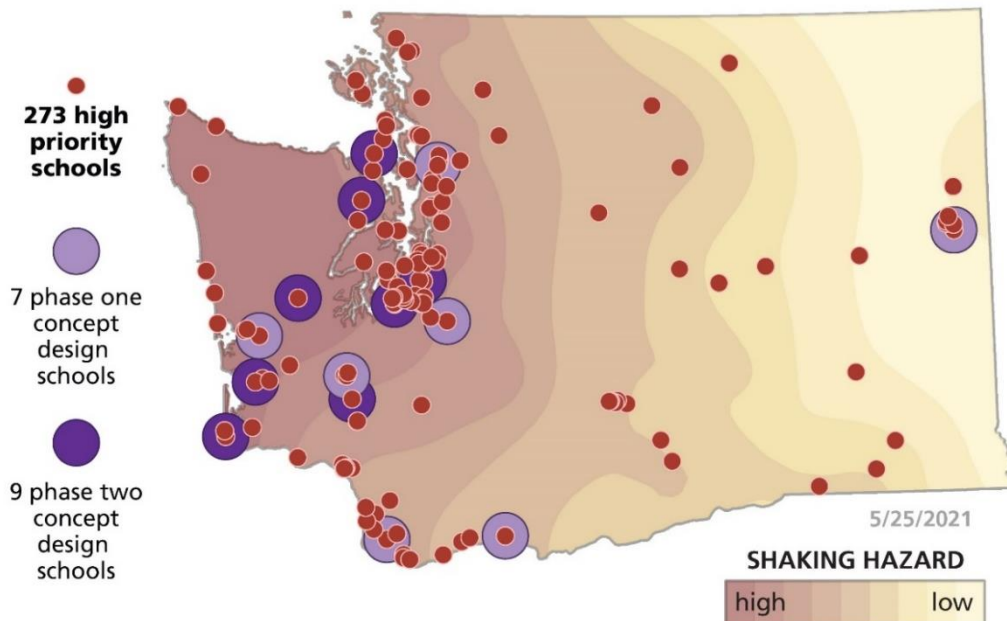


Figure 4.6-2. Map Showing High Priority Schools (red dots) and High Priority Phase 1 & 2 Concept Design Schools (WA DNR, 2021).



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WASHINGTON SCHOOL SEISMIC SAFETY PROJECT MODERATE PRIORITY SCHOOLS

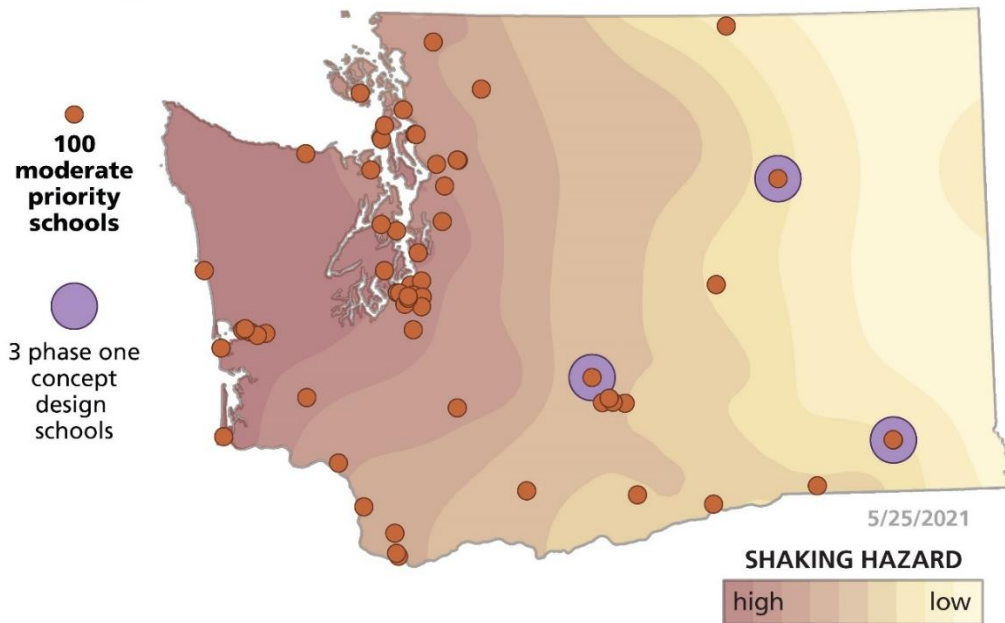


Figure 4.6-3. Map Showing Moderate Priority Schools (Orange dots) and Moderate Priority Phase 1 & 2 Concept Design Schools (WA DNR, 2021).



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WASHINGTON SCHOOL SEISMIC SAFETY PROJECT LOWER PRIORITY SCHOOLS

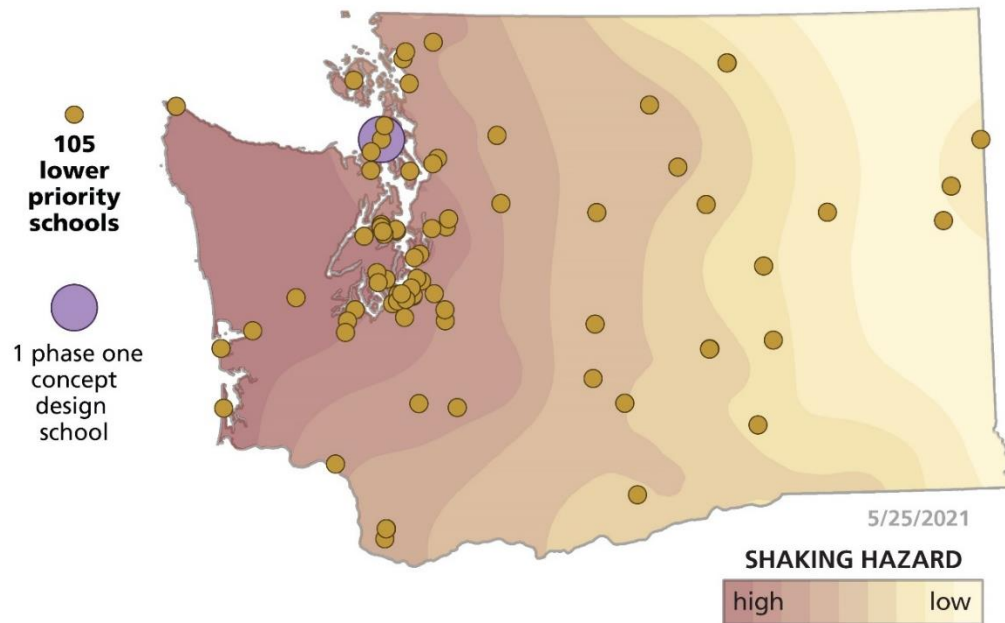


Figure 4.6-4. Map Showing Lower Priority Schools (yellow dots) and High Priority Phase 1 & 2 Concept Design Schools (WA DNR, 2021).

4.7 Fire Station Results

The Phase 1 & Phase 2 seismic assessment of seven fire stations resulted in similar observations to the school buildings that were assessed. Older fire stations (pre-1975) and fire stations constructed of heavier materials (URM, reinforced masonry, non-ductile concrete) are significantly more vulnerable than more modern wood- or steel-framed fire stations. Fire stations are considered essential facilities that need to be functioning and occupant-ready to perform essential community services following an earthquake. As a result, older fire station buildings should be highly prioritized for seismic retrofit or replacement by state, city, and county agencies as funding becomes available.

The seven fire stations assessed in Phase 1 and Phase 2 of this study are a very small sampling of the fire stations throughout the state. Based upon the structural engineers' experience in working with fire districts and city agencies in and around the greater Puget Sound area, there are many other fire stations in operation that were built prior to 1975 and have vulnerable URM, reinforced masonry, and non-ductile concrete structural systems. A number of fire districts and communities have successfully passed capital bonds and levies over the past couple of decades to replace or retrofit their older fire stations. However, similar to schools, there are many other fire districts and communities statewide that have not had the economic means or support to upgrade or replace their aging fire stations and may need state assistance to do so.

5.0 Concept-Level Seismic Upgrades Summary

5.1 Concept-Level Design Seismic Upgrades Cost Estimate Summary

Seventeen school buildings were selected to receive concept-level seismic upgrade designs and cost estimates as part of Phase 2. The buildings were selected from the list of both Phase 1 and Phase 2 schools. Initially, a list of high-risk school buildings was generated by the project team. Then, the school districts who owned those buildings were surveyed to see if they wanted to participate in receiving concept-level seismic upgrade designs. The intent was also to see if any work was already planned to occur on the buildings, to confirm that the buildings had not already received seismic upgrades, and to confirm that the school districts are not planning to replace the buildings soon. Most school districts replied to the survey, but some did not. From an initial list of approximately 50 high-risk schools, 17 were selected. Additionally, the concept-level upgrade design school buildings were selected prior to the completion of the Phase 2 seismic evaluations, so not all the data from the Phase 2 seismic evaluations was available to review in selecting the buildings.

Additionally, an attempt was made to include a variety of building construction types in the selected buildings rather than just focus on limited types of construction (e.g. only URM or nonductile concrete). As a consequence, some less vulnerable wood buildings were selected to receive concept-level designs. These wood buildings should be indicative of Washington State light-frame construction, which was the dominant construction type during the 20th Century, and the magnitude of the total costs to seismically upgrade some of these buildings is less than some of the other construction types. The selected school buildings included a few. Figure 5.1-1 shows a map of the 17 selected school buildings.

When the Phase 1 cost estimates were developed, the OSPI School Seismic Retrofit Program (SSRP) did not yet exist. As such, the Phase 1 cost estimates were not developed with the idea that they would be used as part of that program. The Phase 1 cost estimates only included estimates of the construction costs and did not include any soft cost items such as architecture/engineering design fees, project administration fees, building permitting fees, construction testing fees, or other fees. The Phase 1 cost estimates also did not include any escalation to account for inflation over time because it was not known when or if construction would start. Conversely, the Phase 2 cost estimates were developed with the knowledge that the OSPI School Seismic Retrofit Program exists, and the project team worked closely with OSPI to develop cost estimates that could work within that program.

WASHINGTON SCHOOL SEISMIC SAFETY PROJECT PHASE 2 CONCEPT LEVEL DESIGN SCHOOLS

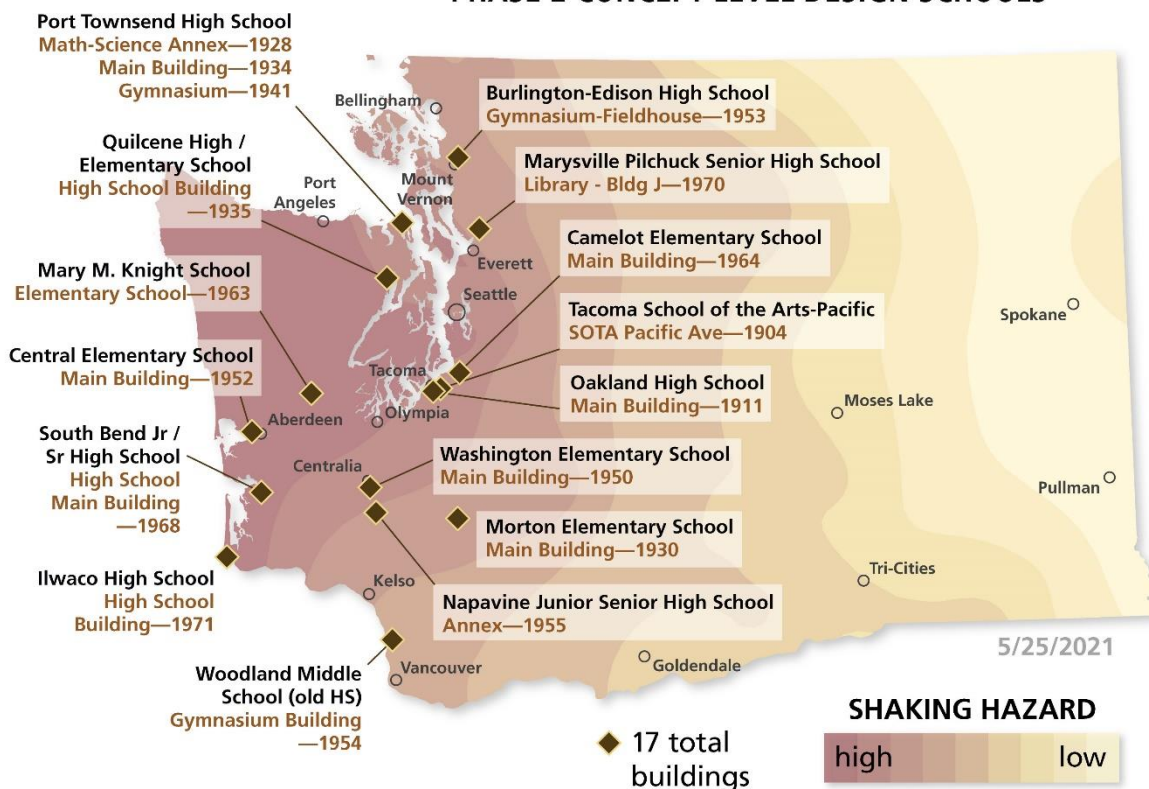


Figure 5.1-1. Map Showing Buildings Selected for Phase 2 Concept-Level Seismic Upgrade Designs (WA DNR, 2021).

Even so, it is important to emphasize that the estimated costs developed for these buildings are preliminary in nature, as they are based on the results of the Tier 1 seismic screening checklists and engineering design judgment and have not been substantiated by more-detailed analyses.

Relative to construction cost estimates that are based upon construction drawings prepared by architecture and engineering firms for a defined scope of work, these concept-level seismic upgrade reports constitute a pre-design level scope of information due to the screening level of engineering and field investigation. Thus, for cost estimating and contingency purposes, these concept-level seismic upgrade designs would be considered as a design that is approximately 1 percent complete. This is in comparison to a 30 percent schematic design cost estimate where a full architecture and engineering design team has spent significantly more time observing existing conditions, performing other assessment studies (such as hazmat abatement, accessibility, energy and so on), and coordinating with school districts to accurately define the scope and phasing considerations in developing a set of construction documents for a renovation project. The concept upgrade designs received some input and review from architects; however, no architectural design has been completed at this time. In addition, there has been no

involvement from mechanical, electrical, or fire protection engineers. The estimated costs for the seismic upgrade will change as the designs are further developed.

For this preliminary assessment of probable costs, an estimate of the current year (2021) construction costs of the probable scope of work was developed. Then a -20 percent (low) to +50 percent (high) range variance was used to develop the construction cost estimate range for the concept-level scope of work. The -20 percent to +50 percent range variance guidance is from table 1 of the AACE International Recommended Practice 56R-08, *Cost Estimate Classification System for Class 5 Estimates*. The range of a Class 5 construction cost estimate is due to the limited design completeness of 0 percent to 2 percent and is defined as -20 percent to +50 percent as noted. It is unlikely that the actual construction costs will equal the estimated cost values, but it is the intent that the actual construction costs will fall within the -20 percent to +50 percent ranges.

Cost estimates also factor in when the construction phase of a project will commence to account for escalation in construction costs. Because these cost estimates are used to assist OSPI and school districts with future funding requests or programming needs, it is not known at this time if or when these seismic upgrades will be implemented. To account for some cost escalation however, the cost estimates prepared for this study assume a mid-point of construction occurring at the end of 2022. The cost estimates were developed in the beginning of 2021 and escalated at a rate of 6 percent per year to the end of 2022, effectively adding a 12 percent markup to the 2021 cost estimates.

Soft costs were included in the cost estimates as 40 percent of the estimated construction costs. Soft costs can include things like the owner's general overhead costs, project management costs, financing/bond costs, administration/contract/accounting costs, review of plans, value engineering studies, equipment, fixtures, furnishings and technology, and relocation of the school staff and students during construction. The soft costs used for the projects that total 40 percent are:

A+E Design	10%
QA/QC Testing	2%
Project Administration	2%
Owner Contingency	11%
Average Washington State Sales Tax	9%
Building Permits	6%

It is normal for soft costs to vary from owner to owner. However, based upon the engineering firm's experience in K-12 school projects in Washington, we assume that 40 percent of the probable construction cost is a reasonable and appropriate soft cost recommendation for budgeting purposes. Therefore, we also strongly suggest that each owner develop their own soft costs as part of their budgeting process and not rely solely on the recommended percentage that is stated here.

Table 5.1-1 lists the estimated total cost of each seismic upgrade concept design for Phase 2 buildings. The costs listed include both construction costs and soft costs.

Table 5.1-1. School Seismic Upgrade Total Cost Summary Grouped By Building Type (Construction Cost +Soft Costs).

School District, School Building, Bldg. Type	Original Date of Construction	ASCE 41 Level of Seismicity / Site Class	Performance Objective	Bldg. Gross Area (SF)	Total Upgrade Cost Range \$/SF (Total)			Estimated Costs, \$/SF (Total)
Hoquiam, Central Elementary School, Main Bldg., Reinforced Concrete	1952	High / D	Life Safety	38,946	\$110 (\$4.27M)	-	\$205 (\$8.01M)	\$137 (\$5.34M)
Morton, Morton Elementary School, Main Bldg., Reinforced Concrete	1948	High / C	Life Safety	25,200	\$177 (\$4.45M)	-	\$331 (\$8.35M)	\$221 (\$5.57M)
Quilcene, Quilcene K-12 School, High School Bldg., Reinforced Concrete	1935	High / D	Life Safety	7,860	\$199 (\$1.59M)	-	\$373 (\$2.99M)	\$249 (\$1.99M)
<i>Concrete Shear Wall Averages</i>	1945			24,002	\$162	-	\$303	\$202
Burlington-Edison, Burlington-Edison High School, Gym/Fieldhouse, Reinforced Masonry	1953	High / D	Life Safety	50,133	\$100 (\$5.00M)	-	\$187 (\$9.37M)	\$124 (\$6.25M)
Centralia, Washington Elementary School, Main Bldg., Reinforced Masonry	1950	High / D	Life Safety	51,063	\$151 (\$7.73M)	-	\$284 (\$14.49M)	\$189 (\$9.66M)
Mary M. Knight, Mary M. Knight School, Elementary School Bldg., Reinforced Masonry	1963	High / D	Life Safety	13,333	\$91 (\$1.22M)	-	\$171 (\$2.29M)	\$114 (\$1.53M)
Marysville, Marysville-Pilchuck High School, Library (Bldg. J), Reinforced Masonry	1970	High / D	Life Safety	19,772	\$131 (\$2.59M)	-	\$245 (\$4.85M)	\$163 (\$3.23M)
<i>Reinforced Masonry Averages</i>	1959			33,575	\$118	-	\$222	\$148
Port Townsend, Port Townsend High School, Gym, Unreinforced Masonry	1941	High / D	Life Safety	34,112	\$49 (\$1.68M)	-	\$92 (\$3.15M)	\$61 (\$2.10M)

Table 5.1-1. School Seismic Upgrade Total Cost Summary Grouped By Building Type (Construction Cost +Soft Costs).

School District, School Building, Bldg. Type	Original Date of Construction	ASCE 41 Level of Seismicity / Site Class	Performance Objective	Bldg. Gross Area (SF)	Total Upgrade Cost Range \$/SF (Total)			Estimated Costs, \$/SF (Total)
Port Townsend, Port Townsend High School, Math- Science Annex, Unreinforced Masonry	1928	High / D	Life Safety	13,169	\$90 (\$1.19M)	-	\$169 (\$2.24M)	\$113 (\$1.49M)
Tacoma, Tacoma School of the Arts, Pacific Bldg., Unreinforced Masonry	1904	High / C	Life Safety	21,601	\$275 (\$5.94M)	-	\$516 (\$11.14M)	\$344 (\$7.43M)
Woodland, Woodland Middle School, Gymnasium, Unreinforced Masonry	1954	High / E	Life Safety	23,100	\$120 (\$2.77M)	-	\$224 (\$5.19M)	\$150 (\$3.46M)
<i>Unreinforced Masonry Averages</i>	1932			22,996	\$134	-	\$250	\$167
Clover Park, Custer Elementary School, Classroom Bldg., Wood Framed	1952	High / D	Life Safety	40,304	\$179 (\$7.23M)	-	\$336 (\$13.55M)	\$224 (\$9.04M)
Federal Way, Camelot Elementary School, Main Bldg., Wood Framed	1964	High / C	Life Safety	41,111	\$134 (\$5.50M)	-	\$250 (\$10.32M)	\$167 (\$6.88M)
Napavine, Napavine Jr/Sr High School, Annex Bldg., Wood Framed	1955	High / C	Life Safety	11,274	\$87 (\$988K)	-	\$164 (\$1.85M)	\$109 (\$1.24M)
Quilcene, Quilcene K-12 School, Middle School Bldg., Wood Framed	1964	High / C	Life Safety	9,438	\$156 (\$1.48M)	-	\$293 (\$2.78M)	\$195 (\$1.85M)
South Bend, South Bend Jr/Sr High School, HS Main Bldg., Wood Framed	1968	High / E	Life Safety	51,000	\$103 (\$5.23M)	-	\$192 (\$9.81M)	\$128 (\$6.54M)
Ocean Beach, Ilwaco High School, Main Bldg., Wood Framed	1970	High / D	Life Safety	89,249	\$137 (\$12.20M)	-	\$256 (\$22.88M)	\$171 (\$15.26M)
<i>Wood Framed Averages</i>	1962			40,396	\$133	-	\$249	\$166
OVERALL AVERAGES	1951			31,804	\$135	-	\$252	\$168

The estimated costs to seismically upgrade the 32 school buildings that received the concept level design study ranged from \$63,000 to \$5,000,000 in Phase 1 and from \$1,240,000 to \$15,260,000 in Phase 2. It should be noted that the Phase 1 costs do not include soft costs or escalation to the year 2022. The Phase 1 costs are construction costs only. In addition, the Phase 1 concept upgrade schools included several schools in moderate seismicity areas and low seismicity areas. Consequently, the costs from Phase 1 and Phase 2 are not directly comparable.

Estimated probable construction costs, including soft costs, for the seismic upgrades of the two fire station are in Table 5.1-2. Assessments of costs for the two Phase 2 fire stations have been prepared as part of this study. The estimated upgrade costs range from approximately \$123 per square foot to \$278 per square foot for the reinforced masonry and unreinforced masonry fire stations, respectively. These are merely two data points of approximate renovation costs needed to bring these fire stations to an Immediate Occupancy structural performance objective, but they can be used with other planning level estimates of fire stations to help quantify the financial need at a higher overview level. Past studies of fire station seismic upgrades that we have worked on have similar ranges of probable costs per square foot. However, like any other fire station or school building, these costs are highly variable depending on building age, construction type, historic significance, area, seismicity, and site conditions. Specific seismic upgrade costs for a given fire station will require further study by a structural engineer and architect team.

Table 5.1-2. Fire Station Seismic Upgrade Total Cost Summary (Construction Cost +Soft Costs).

City, Fire Dept, Fire Station, Bldg. Type	Original Date of Construction	ASCE 41 Level of Seismicity / Site Class	Structural Performance Objective	Bldg. Gross Area (SF)	Total Upgrade Cost Range \$/SF (Total)			Estimated Costs, \$/SF (Total)
						-		
Hoquiam, Hoquiam Fire Department, 8th Street Station, Reinforced Masonry	1971	High / E	Immediate Occupancy	12,908	\$99 (\$1.28M)	-	\$186 (\$2.39M)	\$124 (\$1.6M)
Tacoma, Tacoma Fire Department, Fire Station 4 Unreinforced Masonry	1935	High / C	Immediate Occupancy	6,115	\$222 (\$1.36M)	-	\$416 (\$2.54M)	\$278 (\$1.69M)

5.2 Concept-Level Design Seismic Upgrade Construction Cost Estimate Summary

Soft costs are expected to vary between school districts and seismic upgrade projects. Soft costs also include many different recipients such as architects/engineers, project administrators, inspection agencies and permitting agencies. On the other hand, construction costs should be borne by the general contractor hired to construct the seismic upgrades.

Table 5.2-1 shows the estimated construction costs for each concept-level seismic upgrade design. The estimated soft costs are excluded from the table. Also, notably, the construction costs listed in the table do not include sales tax as sales tax is considered a soft cost.

Table 5.2-1. Seismic Upgrade Total Construction Cost Summary Grouped by Building Type.

School District, School Building, Bldg. Type	Original Date of Construction	ASCE 41 Level of Seismicity / Site Class	Performance Objective	Bldg. Gross Area (SF)	Total Upgrade Cost Range \$/SF (Total)			Estimated Costs, \$/SF (Total)
Hoquiam, Central Elementary School, Main Bldg., Reinforced Concrete	1952	High / D	Life Safety	38,946	\$78 (\$3.05M)	-	\$147 (\$5.72M)	\$98 (\$3.81M)
Morton, Morton Elementary School, Main Bldg., Reinforced Concrete	1948	High / C	Life Safety	25,200	\$70 (\$3.18M)	-	\$237 (\$5.97M)	\$158 (\$3.98M)
Quilcene, Quilcene K-12 School, High School Bldg., Reinforced Concrete	1935	High / D	Life Safety	7, 860	\$142 (\$1.14M)	-	\$267 (\$2.13M)	\$178 (\$1.42M)
<i>Concrete Shear Wall Averages</i>	1945			24,002	\$116	-	\$217	\$144
Burlington-Edison, Burlington-Edison High School, Gym/Fieldhouse Bldg., Reinforced Masonry	1953	High / D	Life Safety	50,133	\$71 (\$3.57M)	-	\$133 (\$6.69M)	\$89 (4.46M)
Centralia, Washington Elementary School, Main Bldg., Reinforced Masonry	1950	High / D	Life Safety	51,063	\$108 (\$5.52M)	-	\$203 (\$10.35M)	\$135 (\$6.90M)
Mary M. Knight, Mary M. Knight School, Elementary School Bldg., Reinforced Masonry	1963	High / D	Life Safety	13,333	\$65 (\$871K)	-	\$122 (1.63M)	\$81 (\$1.09M)
Marysville, Marysville-Pilchuck High School, Library (Bldg. J), Reinforced Masonry	1970	High / D	Life Safety	19,772	\$93 (\$1.85M)	-	\$175 (\$3.46M)	\$117 (\$2.31M)
<i>Reinforced Masonry Averages</i>	1959			33,575	\$84	-	\$158	\$154
Port Townsend, Port Townsend High School, Gym., Unreinforced Masonry	1941	High / D	Life Safety	34,112	\$35 (\$1.20M)	-	\$66 (\$2.25M)	\$44 (\$1.50M)

Table 5.2-1. Seismic Upgrade Total Construction Cost Summary Grouped by Building Type.

School District, School Building, Bldg. Type	Original Date of Construction	ASCE 41 Level of Seismicity / Site Class	Performance Objective	Bldg. Gross Area (SF)	Total Upgrade Cost Range \$/SF (Total)			Estimated Costs, \$/SF (Total)
Port Townsend, Port Townsend High School, Math- Science Annex, Unreinforced Masonry	1928	High / D	Life Safety	13,169	\$65 (\$852K)	-	\$121 (\$1.6M)	\$81 (\$1.06M)
Tacoma, Tacoma School of the Arts, Pacific Bldg., Unreinforced Masonry	1904	High / C	Life Safety	21,601	\$196 (\$4.24M)	-	\$368 (\$7.96M)	\$246 (\$5.30M)
Woodland, Woodland Middle School, Gymnasium Bldg., Unreinforced Masonry	1954	High / E	Life Safety	23,100	\$86 (\$1.98M)	-	\$160 (\$3.70M)	\$107 (\$2.47M)
<i>Unreinforced Masonry Averages</i>	1932			23,025	\$95	-	\$279	\$119
Clover Park, Custer Elementary School, Classroom Bldg., Wood Framed	1952	High / D	Life Safety	40,304	\$128 (\$5.16M)	-	\$240 (\$9.68M)	\$160 (\$6.45M)
Federal Way, Camelot Elementary School, Main Bldg., Wood Framed	1964	High / C	Life Safety	41,111	\$95 (\$3.293M)	-	\$179 (\$7.37M)	\$119 (\$4.91M)
Napavine, Napavine Jr/Sr High School, Annex, Wood Framed	1955	High / C	Life Safety	11,274	\$62 (\$706K)	-	\$117 (\$1.32M)	\$78 (\$882K)
Quilcene, Quilcene K-12 School, Middle School Bldg., Wood Framed	1964	High / C	Life Safety	9,438	\$111 (\$1.06M)	-	\$209 (\$1.99M)	\$139 (\$1.32M)
South Bend, South Bend Jr/Sr High School, HS Main Bldg., Wood Framed	1968	High / E	Life Safety	51,000	\$73 (\$3.74M)	-	\$137 (\$7.01M)	\$92 (\$4.67M)
Ocean Beach, Ilwaco High School, Main Bldg., Wood Framed	1970	High / D	Life Safety	89,249	\$98 (\$8.72M)	-	\$183 (\$16.35M)	\$122 (\$10.90M)
<i>Wood Framed Averages</i>	1962			40,425	\$95	-	\$178	\$118
OVERALL AVERAGES	1951			31,844	\$96	-	\$180	\$120

5.3 Potential Cost Savings If Seismic Upgrades Combined with Other Construction

A significant portion of the structural upgrade costs are due to the fact that the seismic upgrades take place in existing buildings with existing finishes and existing nonstructural components. The costs to temporarily remove and replace the architectural, mechanical, electrical, and plumbing equipment is significant. Table 5.3-1 lists the estimated construction costs (soft costs excluded) if seismic upgrades are combined with other architectural, mechanical, electrical, plumbing, and fire protection upgrades that are already planned to take place (such as full-building modernizations). The costs listed in Table 5.3-1 were developed by deleting the architectural, mechanical, electrical, plumbing and fire protection costs from the construction cost estimates. The table indicates that the average building may see up to a 70 percent reduction in seismic upgrade costs when seismic upgrades are combined with other work. The precise reduction in costs may depend on the ultimate scope of work of the seismic upgrades and the other work conducted at the same time. Nonetheless, significant savings can be realized by combining seismic upgrades with other types of work, such as re-roofing projects or school modernizations.

Table 5.3-1. Seismic Upgrade Estimated Construction Costs if Combined with Architectural, Mechanical, Electrical, Plumbing and Fire Protection Upgrades.

School District, School Building, Bldg. Type	Original Date of Constr.	Bldg. Gross Area (SF)	Estimated Construction Cost	Reduction in Cost (Percentage)
Hoquiam, Central Elementary School, Main Building, Reinforced Concrete	1952	38,946	\$1.51M	48%
Morton, Morton Elementary School, Main Building, Reinforced Concrete	1948	25,200	\$921K	60%
Quilcene, Quilcene K-12 School, High School Building, Reinforced Concrete	1935	7,860	\$192K	72%
<i>Concrete Shear Wall Averages</i>	1945	24,002	\$873K	60%
Burlington-Edison, Burlington-Edison High School, Gym/Fieldhouse Building, Reinforced Masonry	1953	50,133	\$1.81M	47%
Centralia, Washington Elementary School, Main Building, Reinforced Masonry	1950	51,063	\$1.06M	72%
Mary M. Knight, Mary M. Knight School, Elementary School Building, Reinforced Masonry	1963	13,333	\$290K	65%
Marysville, Marysville-Pilchuck High School, Library (Building J), Reinforced Masonry	1970	19,772	\$636K	64%
<i>Reinforced Masonry Averages</i>	1959	33,575	\$949K	62%

Table 5.3-1. Seismic Upgrade Estimated Construction Costs if Combined with Architectural, Mechanical, Electrical, Plumbing and Fire Protection Upgrades.

School District, School Building, Bldg. Type	Original Date of Constr.	Bldg. Gross Area (SF)	Estimated Construction Cost	Reduction in Cost (Percentage)
Port Townsend, Port Townsend High School, Gym Building, Unreinforced Masonry	1941	34,112	\$682K	32%
Port Townsend, Port Townsend High School, Math-Science Annex, Unreinforced Masonry	1928	13,169	\$107K	82%
Tacoma, Tacoma School of the Arts, Pacific Building, Unreinforced Masonry	1904	21,601	\$982K	69%
Woodland, Woodland Middle School, Gymnasium Building, Unreinforced Masonry	1954	23,100	\$744K	76%
<i>Unreinforced Masonry Averages</i>	1932	23,025	\$629K	65%
Clover Park, Custer Elementary School, Classroom Building, Wood Framed	1952	40,304	\$996K	72%
Federal Way, Camelot Elementary School, Main Building, Wood Framed	1964	41,200	\$419K	85%
Napavine, Napavine Jr/Sr High School, Annex Building, Wood Framed	1955	11,274	\$14K	98%
Quilcene, Quilcene K-12 School, Middle School Building, Wood Framed	1964	9,438	\$120K	86%
South Bend, South Bend Jr/Sr High School, HS Main Building, Wood Framed	1968	51,000	\$462K	85%
Ocean Beach, Ilwaco High School, Main Building, Wood Framed	1970	89,249	\$1.02M	83%
<i>Wood Framed Averages</i>	1962	40,425	\$506K	85%
OVERALL AVERAGES	1951	31,844	\$708K	70%

5.4 Effects of Liquefaction on Seismic Upgrades Construction Costs

The costs of seismically upgrading school buildings on liquefiable sites generally consists of two components: 1) the cost to enhance the seismic resistance of the building system; and 2) foundation upgrade by using deep foundations or ground improvement to mitigate liquefaction effects.

The options feasible to mitigate effects of liquefaction are highly dependent on the magnitude of liquefaction-induced ground deformations, tolerable foundation settlement, and lateral ground deformation criteria specified by the building code provisions. For sites with small amounts of foundation settlement and lateral ground deformation, minimal enhancement of the building foundations is required. For sites with moderate amounts of foundation settlement and lateral ground deformation, with conventional strip footings and isolated spread footings, tie beams would be needed. For sites with high amounts of foundation settlement and lateral ground deformation, shallow foundations will need to be enhanced by implementing ground improvement methods (aggregate piers, compaction piling, jet grouting) with tie beams, or using different foundation types such as raft/mat foundation or piles (pin piling, augercast piling, micro-piling). The seismic upgrade cost estimates are greatly dependent on which mitigation option is required.

5.5 Fire Station Cost Estimates

Assessments of probable construction costs for the two Phase 2 fire stations have been prepared as part of this study. The estimated upgrade costs are approximately \$82 per square foot to \$192 per square foot for the reinforced masonry and unreinforced masonry fire stations, respectively. These are merely two data points of approximate renovation costs needed to bring these fire stations to an Immediate Occupancy structural performance objective, but can be used with other planning level estimates of fire stations to help quantify the financial need at a higher overview level. Past studies of fire station seismic upgrades that the structural engineers have worked on had similar ranges of probable costs per square foot. However, like any other fire station or school building, these costs are highly variable depending on building age, construction type, historic significance, area, seismicity, and site conditions. Specific seismic upgrade costs for a given fire station will require further study by a structural engineer and architect team.

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6.0 Economic Considerations

6.1 Introduction

Seismic retrofit needs across the state pose a challenge for policymakers. Buildings vary in age and structural performance level, the timing and size of both seismic risk and potential project funding are uncertain, and government spending must be weighed against public benefits. There has been general consensus that seismic retrofits are warranted for high-risk buildings in high seismic areas of Washington State. However, the precise magnitude of the benefits of school retrofits in comparison to the costs of such retrofits has never been studied in detail.

The Washington State Legislature started a school seismic retrofit program in 2020 that is administered by OSPI. This program is a first-of-its-kind in Washington State, and the Legislature is to be commended for starting the program. The Washington State Legislature has already prioritized seismic school retrofits by approving \$13.24 million in 2020 for retrofitting grants to OSPI. These funds were directed to be prioritized for high risk and high deficiency buildings. Another \$39 million has been approved for the coming 2021-2023 biennium to continue the retrofitting program.

Economics is a valuable tool that empowers policymakers to make informed decisions on the optimal allocation of scarce resources to maximize benefits. Appendix B.5 includes a detailed discussion of economic considerations and the importance of including a discussion of benefits and costs in decision-making. A summary of the appendix is included in this section.

6.2 Benefit-Cost Analysis and Case Study

At its most basic level, Benefit-Cost Analysis (BCA) is a tool for comparing alternatives. BCA can empower policymakers to know that they are optimizing their decision-making and allocating funding and other resources in the most appropriate ways. Done correctly, and recognizing its limitations, BCA provides a well-defined method for examining the value of an action and tradeoffs among different actions. Measuring benefits and costs over time helps to identify alternatives that maximize the net benefit. If an action has benefits that exceed the costs, then this suggests that the action should be taken. Alternatively, if an action has benefits that do not exceed the costs, then that suggests the action should not be taken. In this way, BCA can provide a framework to decide what, if any, action should take place.

6.2.1 Benefits and Costs Over Time

Economics uses discounting on benefits and costs over time to translate future impacts to present terms. People value benefits they receive now more than they value benefits they would receive in the future (e.g. people value receiving \$10 today more than they would value receiving \$10 in the future, even when adjusted for inflation). Similarly, people value costs they must pay now more significantly than costs they must pay in the future. It is important to note that these considerations are irrespective of inflation and it is important to note that a discount rate is distinct from interest rates used in other circumstances. The purpose of the discount rate used in BCA is to relate future benefits/costs into their equivalent present value.

Considering benefits and costs over time is particularly relevant when considering school retrofits as it captures the impact of receiving benefits in the uncertain long-term and paying costs certainly in the short-term. That is, school seismic retrofits will be completed now, but the benefits of those seismic retrofits will only be realized when an earthquake occurs. Earthquakes are inherently uncertain, and it is unknown if a large magnitude earthquake will occur near a particular school within the next 5 years or within the next 100 years. Though the annual probability of certain magnitude earthquakes are well-known. So, even though there is significant uncertainty about whether a particular earthquake will occur within a certain year, the probability of a particular earthquake occurring within a given year is well understood and readily quantified. If a large earthquake occurs within 1-5 years after a seismic retrofit, then the relative benefits are likely to be substantial. However, if a large magnitude earthquake does not occur until 50 years after a seismic retrofit, then the relative benefits are smaller.

Looking at these impacts over time will help to determine what buildings should be retrofitted and at what point in time. This is useful considering that some costs such as repair costs may grow over time as buildings become less resilient to a seismic event. Additionally, some benefits may grow over time, for example, a growing population indicates that more people would receive the public benefit of safety over time. The temporal component of BCA can also help to determine the annualized cost of larger projects.

Of particular importance is the selection of an appropriate discount rate for comparing benefits and costs across time. Generally speaking, there are two basic frameworks for discount rates, the finance-equivalent discount rate and the social-welfare-equivalent discount rate. The finance-equivalent discount rate is derived from the expected rate of return on investment for capital investments, and is representative of forgone returns on resources spent in the present rather than in the future. In practice, 7% is usually used as this finance-equivalent discount rate, and would be most appropriately applied to evaluating the impacts of regulatory policy on capital allocation¹ (i.e. the costs of seismic upgrades).

However, since seismic upgrades would produce both capital costs and public benefits, the social-welfare-equivalent discount rate should be used for capturing “society’s rate of time preference” for consumption in the present compared to the future. Oftentimes, a 3% discount rate is used to account for intergenerational and long time horizon decisions².

6.2.2 Hypothetical Case Study Applying Benefit Cost Analysis

To demonstrate how BCA can inform funding decisions, the above BCA framework is applied to a hypothetical school. The elementary school main building is a two-story concrete structure with brick veneer. The 1948 building is constructed on level ground and is located in western Washington. The building is rectangular in plan, 212 feet by 66 feet, with a maximum roof height of around 42 feet. Building construction consists of concrete walls with brick veneer. The roof system is a flexible diaphragm composed of wood trusses. The floor system is a

¹ Office of Management and Budget. Circular A-4. Retrieved from: https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/

² Ibid.

flexible diaphragm composed of wood joists. The building shares the site with a gymnasium building and two covered play sheds. The school serves an area of 1,000 single-family homes with an average property value of \$150,000.

Table 6.2.2-1. Hypothetical School Information.

Location:	Western Washington
Enrollment:	176 Students
Staff Size:	10 Teachers and administrators
School Type:	Elementary School
Number of Stories:	2
Year Built:	1948
Square Footage:	25,200
Construction Type:	Nonductile Concrete Shear Walls

Table 6.2.2-2. Seismic Information.

ASCE 41 Level of Seismicity:	High	
Soil Site Class:	C	
V_{S30}:	455	m/s
S_S (BSE-2N):	1.084	g
S₁ (BSE-2N):	0.42	g
S_S (BSE-2E):	0.779	g
S₁ (BSE-2E):	0.305	g

Table 6.2.2-3. Seismic Upgrade Information.

Estimated Seismic Upgrade Cost per Square Foot:	221	Dollars per Square Foot
Existing Building Replacement Value:	375-425	Dollars per Square Foot
Estimated Seismic Upgrade Cost with Full-Building Modernization:	88	Dollars per Square Foot

The results of the hypothetical BCA case study indicate that the expected benefits of seismic upgrades to this building range between \$5.08 million and \$7.97 million depending on whether a 7% or 3% discount rate is used, respectively. The cost of the seismic upgrade is estimated to be \$5.57 million (\$221 per square foot). This indicates the benefits generally exceed the costs of upgrade, and the benefit cost ratio ranges between 0.9 and 1.4, depending on the discount rate. A benefit cost ratio that exceeds 1.0 indicates that seismic upgrades make sense economically. However, if seismic upgrades are combined with a full-building modernization where architectural, mechanical, electrical and plumbing costs are allocated separately from the seismic upgrade costs, the cost of seismic upgrade is estimated to be \$2.23 million. In this scenario the benefits significantly exceed the costs of seismic upgrade, and the benefit cost ratio ranges between 2.3 and 3.5. A more-detailed description of the case study is include in Appendix B.5.

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7.0 Recommendations

This section contains our engineering recommendations based upon the results, findings, and reporting in both phases of the Washington State School Seismic Safety Project. These recommendations are not presented in any particular order and should be considered with the same emphasis regarding improving the seismic safety and preparedness of our schools.

The results and findings from this study should be used to inform the Washington State Legislature and policy makers of the estimated seismic risks in K-12 public school buildings statewide and be considered when coming up with policies and funding mechanisms to mitigate those risks. The screening reports, concept reports, and structural safety risk information provided should be used by OSPI and the school districts to develop mitigation strategies to do seismic improvement projects of school buildings (either done voluntarily or as part of a modernization) or to serve as guidance in providing further engineering investigation and analysis of school buildings.

7.1 Recommendations for Enhanced School Seismic Safety and Performance


7.1.1 Use of the EPRS Structural Safety Sub-Rating Reporting

An objective of this study was to inform school districts of the seismic deficiencies of their buildings and possible ways to mitigate them. The ‘Earthquake Performance Rating System (EPRS) ASCE 41-13 Translation Procedure’ was chosen to help communicate and prioritize the seismic deficiency mitigation in the seismic screening reports. This process extracts evaluation items (building components) from the ASCE 41 Tier 1 checklists that need to be determined cumulatively as “Compliant” in order to increase a building’s structural safety rating from a one-star rating (risk of collapse in multiple or widespread locations) to a two-star rating (risk of collapse in isolated locations) and then to the recommended goal of a three-star rating (the Life Safety structural performance objective). Extracting and categorizing these evaluation items in this manner creates a prioritized list of seismic deficiencies, as shown in Figure 7.1-1. The risk rating and prioritized list of deficiencies are provided to schools in their individual building screening reports.

This is intended to be used as a mitigation strategy to provide further engineering investigation and analysis, and seismic improvement projects (either done voluntarily or as part of a modernization), to increase the seismic safety of the building and consequently increase its structural safety risk rating. It is highly encouraged and recommended that school districts and structural engineers further study the ratings and assessments of their oldest and most vulnerable buildings and discuss how best to improve the seismic safety of their school facilities.

Table -5. Identified Seismic Evaluation Items to Address for an improved  **2-STAR Rating**

Evaluation Item	Tier 1 Screening	Description
Vertical Irregularities	Noncompliant	It does not appear that vertical elements are continuous to the foundation. Further investigation should be performed prior to retrofit. Lateral system strengthening, such as infilling with CMU or adding new shear walls or braced frames may be appropriate to mitigate seismic risk.
Wall Anchorage	Noncompliant	Out-of-plane wall anchoring is not present based on structural drawings provided. Further investigation should be performed prior to retrofit. Diaphragm reinforcement, including tension ties, blocking, strapping, and diaphragm nailing to provide out-of-plane connection at masonry walls may be appropriate to mitigate seismic risk.
Wood Ledgers	Noncompliant	Connections that induce cross-grain bending in wood ledgers are present. Strengthening of connections through the addition of blocking and anchor straps may be appropriate to mitigate seismic risk.
Transfer to Shear Walls	Unknown	Likely noncompliant condition based on year of construction for pre-benchmark building. Further investigation should be performed.
Cross Ties	Noncompliant	There are no continuous cross ties between diaphragm chords. Further investigation should be performed prior to retrofit. The addition of new cross ties between diaphragm chords or the addition of strap plates to connect existing framing members together may be appropriate to mitigate seismic risk.
Diagonally Sheathed and Unblocked Diaphragms	Noncompliant	Diaphragm is unblocked with spans greater than 40 feet in locations. Further investigation should be performed prior to retrofit. Diaphragm strengthening through the addition of blocking or additional diaphragm nailing may be appropriate to mitigate seismic risk.

Table -6. Identified Seismic Evaluation Items to Mitigate or Further Investigate for an improved  **3-STAR Rating**

Evaluation Item	Tier 1 Evaluation	Description
Adjacent Buildings	Unknown	Limited existing drawings and inadequate access to verify. Further investigation should be performed. Diaphragm reinforcement, shear wall addition, or tying joints together may be appropriate to mitigate seismic risk.
Reinforcing Steel	Noncompliant	The masonry walls are under-reinforced and will likely need to be strengthened for in-plane and out-of-plane seismic loads. FRP or new shear walls may be appropriate to reduce in-plane demand. Steel strongbacks may be appropriate to strengthen out-of-plane capacity.

Figure 7.1-1. EPRS Structural Safety Rating Reporting in Screening Reports .

7.1.2 Consider Funding Incentives Specifically for Seismic Upgrades That Are Included in Nonstructural Maintenance Projects

While the scope of the seismic risk problem may seem extensive, many seismic safety improvements can be made with relatively modest financial investments. For example, if building seismic upgrades are combined with roof replacements, the inclusion of seismic upgrades tends to lead to a relatively small overall cost increase. Seismically upgrading a roof diaphragm with a plywood-sheathing overlay on older shiplap roof deck for example can be done as part of a future re-roofing project where over 90% of the cost would be to remove and replace the nonstructural roofing system. In projects where ceilings need to be removed and replaced, taking the opportunity to brace heavy walls, strengthen the seismic load path, independently support light fixtures, or provide supplemental bracing of sprinkler systems may result in heavily discounted costs compared to a stand-alone seismic upgrade project.

7.1.3 Require Seismic Upgrades When Schools Undergo Major Modernizations

Washington State spends millions of dollars in each biennium to modernize schools. For the most part, these modernization projects do not include seismic upgrades. A substantial cost of seismic upgrades is the removal and replacement of architectural, mechanical, electrical, and

plumbing systems. This study shows that if seismic upgrades are combined with modernizations, the costs of seismic upgrades can be reduced, on average, by 70 percent. Combining seismic upgrades with modernizations has the potential to save Washington State millions of dollars each biennium and allow for much more efficient spending of funds while improving the seismic safety and resilience of communities.

For example, the federal government requires all buildings in high seismic zones that are undergoing renovations/modernizations that exceed 30 percent of the building's value to seismically evaluate their buildings and mitigate any unacceptable risks (NIST RP-8). It is recommended that Washington State consider developing similar guidelines for school buildings and refining Washington State's school modernization policies in the Washington Administrative Code to specifically include school seismic safety improvements to be a required part of school modernization funding and construction programs.

7.1.4 Increase the Seismic Performance and Criteria for the Design of New School Buildings

A well-known trend is that with each building code cycle, new discoveries in geology and lessons learned from recent earthquakes generally result in increases in seismic design forces and more stringent seismic design requirements. It is also understood that incorporating structural enhancements into the design of new buildings has significantly high benefit-to-cost ratios.

The first and main benefit is that a building designed and constructed above minimum building code standards will result in better seismic performance. This provides added safety for the building occupants and increases the likelihood that the building can be re-occupied following an earthquake. A second benefit is that enhanced seismic systems above minimum code standards will also better adapt it to future building codes and seismic design requirements. Both benefits in turn will improve the seismic resiliency of the school buildings themselves and thereby the resiliency of the communities they serve.

A simple way to do this is to encourage school buildings, or portions thereof, to be structurally designed to a higher Risk Category IV (similar to that of essential facilities) instead of what buildings codes currently require: Risk Category II for school buildings with 250 or less occupants, or Risk Category III for school buildings with greater than 250 occupants. Additional ways to enhance the seismic performance such as performance-based design and resiliency-based design can also be encouraged at the state and local levels in further protecting some of the most publicly used buildings in the communities.

7.1.5 Develop a Long-Term Program to Seismically Upgrade or Replace Vulnerable School Buildings

Washington State has many older school buildings that are highly vulnerable to earthquakes. This is an issue shared by school districts all across the state. In reviewing the ICOS database of permanent buildings, there are over 1,000 school buildings that have been built in or before 1960, 70 percent of which are in high-seismic areas west of the Cascade Mountains and 500 buildings of which do not have any record in ICOS of modernizations or additional work since their original construction. There are organizations that could be used as models for a long-term program with the goal of improving seismic safety and resiliency. For example, Seattle Public

Utilities has developed seismic resilience goals the agency plans to achieve for their drinking water system by the years 2045 and 2075.

Due to the extent of the seismic vulnerability of schools, it is financially infeasible to seismically upgrade all vulnerable facilities in a short period of time. If a long-term seismic upgrade program is created to improve school seismic safety over many decades, the annual (or biannual) costs of the program are likely to be modest. When comparing the known financial costs of post-earthquake recovery to the costs of seismic upgrades, in many cases the financial benefits of seismic upgrades far exceed the costs to replace or repair earthquake-damaged buildings. So, not only can seismically upgrading buildings save lives and allow schools to remain open after earthquakes, it can also save a lot of money. Therefore, developing a long-term program to systematically improve seismic safety and resiliency is essential to ensure the future well-being of our schools and the communities they serve, with fiscal savings in mind.

7.1.6 Study and Mimic Seismic Safety Programs in Other Western States

Starting in 2020, Washington State has begun administering a School Seismic Safety Retrofit Grant Program (SSSRP) that provides funding to perform seismic upgrade designs to selected school buildings with subsequent funding to implement the seismic upgrades. It is our recommendation for OSPI to continue to consult with other states or educational agencies such as Oregon, California, Anchorage School District, to enhance the way the SSSRP is administered and awarded and perhaps mimic their best-practices. It is our recommendation that if this SSSRP continues, it eventually include an application process by which school districts can submit seismic upgrade designs and objectives and potentially qualify to receive seismic upgrade funding from the state based on a benefit-costs determination.

7.1.7 Develop a State Program to Inform Communities and School Districts on Seismic Safety and Resilience

State funding through the creation of the SSSRP is a great start and initiative in increasing the seismic safety of school buildings on a statewide level. The future sustainability and effectiveness of this state-funded grant program will need investment and contribution from local communities to lessen the financial burden on the state. Informing seismically vulnerable communities with an educational and seismic safety advocacy program will provide the necessary information and considerations communities need in deciding which initiatives and improvements to support. This program could be a partnership between OSPI, school districts, and the engineering, architecture, and facility management professionals to help limit the resources needed to perform this seismic safety advocacy and outreach.

It is important to note that it is not the intent of this study and report to create an unfunded mandate for school districts to seismically upgrade their schools without associated funding or statewide seismic safety policy support. One of the main objectives of this study is to screen and evaluate the current levels of seismic vulnerabilities of a statewide selection of our older public school buildings and to use the data and information to help quantify funding and policy needs to improve the seismic safety of our public schools. In this process, we are using this data and information to not only inform the Washington State Governor and Legislature of the policy and

funding needs for seismically safe schools, but to also help inform and be an advocate for the public school districts that participated in this statewide study.

Economically, incremental investments in improving Washington's aged and seismically vulnerable public school buildings not only increases protection of students sooner, but also better protects the public's overall investment in school facilities and infrastructure; not only against the highly publicized Cascadia earthquake event, but also for other smaller and potentially more-frequent seismic events. The overall costs of the investment to seismically upgrade the state's most vulnerable buildings is no doubt staggering. However, the cost and time to rebuild a multitude of school buildings at the same time, following a Cascadia type of earthquake event, effecting nearly 750,000 public school students, could be an overwhelming obstacle in Washington State's post-disaster recovery.

7.2 Recommendations for Further Studies

7.2.1 Continue Updating OSPI's ICOS Database and Doing ASCE 41 Tier 1 Seismic Evaluations of School Buildings

Prior condition assessment reports, area plans, and Study and Survey information in OSPI's ICOS database was extremely helpful in doing ASCE 41 Tier 1 seismic assessments in the absence of existing drawings. This same information might also be enough to run through the EPAT and RVS tools as a first step in identifying buildings that could use a further-detailed ASCE 41 Tier 1 Seismic Evaluation. Therefore, it is recommended that OSPI continues to survey school districts to collect the building's structural data to update the ICOS database.

Many school districts have also already completed some level of seismic retrofit on many of their most vulnerable buildings. Some have received full seismic upgrades based on building code at the time of the modernization. Others have received partial and voluntary upgrades based on the funding the districts had available. However, these seismic upgrades are not necessarily captured in OSPI's ICOS database. Talking with each school district to see if seismic improvements have been made to their buildings and what it cost will also allow OSPI to collect the engineering designs and costs for these upgrades as data points for future planning and programming. Explicitly capturing this data in the ICOS database would help the state to know what has already been done and to further understand what it might cost moving forward.

It is also recommended that the structural building data for the ICOS database be gathered by licensed structural engineers through visiting the buildings or reviewing available existing drawings and geotechnical reports. In addition to construction type, year of construction, and prior seismic upgrades, OSPI's ICOS database also tracks vertical and horizontal structural irregularities such as weak/soft stories, discontinuous vertical force resisting systems, in-plane and out-of-plane setbacks, and torsion. These irregularities should be determined by licensed structural engineers who are very familiar and experienced in identifying them as part of their day-to-day work. Also, cataloging building descriptions and construction history narratives, similar to many of the older Study and Survey data, will be extremely valuable to engineers and facility managers in understanding the structural history of the buildings being assessed, a history that often spans multiple generations and school district personnel. This data will be

instrumental for future seismic retrofit projects and for the state's prioritization and validation of state-funded seismic retrofit projects and modernizations. A future project that hires a licensed team of engineers and architects to canvas the state and gather data from school districts, would benefit the state in providing this structural building data in an expert and consistent manner.

ASCE 41 Tier 1 Seismic Evaluations continue to be the preferred structural engineering standard to identify seismic deficiencies specific to each building and can be used to provide a seismic mitigation strategy to school districts. RVS and EPAT can be used as an initial metric to prioritize buildings that should get further Tier 1 seismic evaluations. Engineers however will need to review existing drawings and perform field investigations to adequately assess the seismic safety of a school building.

7.2.2 Further Study of Soil Liquefaction Risks at School Sites

Although geologic data gathering and analyses were performed to determine seismic soil site classes at the school campuses, a geotechnical engineering analysis of the site soils was not part of the scope of the SSSP study. As a result, the geotechnical seismic effects on the existing buildings and their foundations, such as the presence of liquefiable soils, post-earthquake lateral spreading and deformations, and post-earthquake liquefaction settlements, are not as well understood at each school campus.

It is recommended that additional geologic study and geotechnical investigation be completed to augment the shear wave velocity measurements obtained during Phases 1 and 2 of the SSSP. It is recommended that additional geologic studies include groundwater determination and geologic soil classification to assess the aging effects to soil liquefaction resistance. Using this additional information, school building sites can then be categorized into three groups based on soil liquefaction hazard: high, moderate, and low. Sites with high liquefaction hazard include high groundwater with recent or Holocene-aged soil deposits such as artificial fill or alluvial soils. Sites with moderate liquefaction hazard include high groundwater table with Pleistocene-aged soil deposits or soil with high plasticity. Sites with low liquefaction hazard include deep groundwater table or with glacially consolidated soil deposits.

Once the three groups of sites are determined, the measured shear wave velocity data can then be used to perform soil liquefaction analysis using the semi-empirical analysis method to determine the amount of liquefaction-induced ground settlement and lateral deformations. The results of the semi-empirical liquefaction analysis can be used to verify the level of liquefaction hazard and refine the effects of soil liquefaction to the seismic risk of school buildings. This in turn will help define the seismic upgrade scope as it pertains to ground improvements or foundation strengthening which has a significant effect on the seismic upgrade cost estimates. The results of this analysis could also be used to develop a correlation between school sites with shear wave velocity measurements to school sites that do not have shear wave velocity data in the same group of liquefaction hazard level.

Typically, subsurface investigation required to confirm the presence of liquefiable soils and to anticipate what the liquefaction-induced settlements would be across a site requires deep exploration borings, soil testing, groundwater determination, liquefaction hazard analyses, and additional geophysics. This type of enhanced subsurface investigation can be costly for school districts and the state to incur. Performing the recommended geologic studies as described in the

preceding paragraphs above, by licensed geotechnical engineers with expertise in liquefaction hazard analysis and mitigation, will help provide the state with:

- More accurate assessments of liquefaction risks at existing school buildings suspected of having liquefiable soils.
- Cost-efficient methods and strategies in determining the level of liquefaction risk, leveraging the Vs30 measurements already gathered from previous geologic studies (that include the school sites in Phase 1 and Phase 2 of this study).
- Strategies and rough order of magnitude costs to mitigate liquefiable soils or to enhance and strengthen existing different types of building foundation systems to attain a Life Safety Performance Objective in considering post-earthquake liquefaction-induced settlements.

7.2.3 Conduct Benefit-Cost Analysis on High Priority School Buildings

At this time, no large-scale benefit-cost analyses (BCA) have been conducted on Washington State school buildings. It is also not known what the magnitude of the return on investments of seismic upgrades is for Washington State. It may be that for certain buildings the return on investment of seismic upgrades is substantial. For other buildings, it may not be worthwhile to conduct seismic upgrades. Benefit-cost analysis can help to answer these currently unanswered questions. It is recommended that benefit-cost analysis be conducted on a selected portion of school buildings to determine what types of buildings will benefit most from seismic upgrades and to also determine what amount of public spending is optimal to spend each biennium. Benefit-cost analyses can also be used as a criterion in deciding or prioritizing funding for seismic upgrades of vulnerable buildings and for use in helping to secure federal grants such as FEMA's Building Resilient Infrastructure and Communities (BRIC) program.

7.3 Recommendations for Fire Stations

Older fire stations that are constructed of heavier materials (URM, reinforced masonry, non-ductile concrete) are significantly more vulnerable than more modern wood or steel-framed fire stations. Fire stations are considered essential facilities that need to be functioning and occupant-ready to perform essential community services following an earthquake. As a result, older fire station buildings should be highly prioritized for seismic retrofit or replacement by state, city, and county agencies as funding becomes available.

It is recommended that consideration be given to a state-funded grant program similar to SSSP that will assist in seismically upgrading the most seismically vulnerable fire stations. Further study of the state's inventory of fire stations could be performed by structural engineers and architects to help the state administer and prioritize which fire stations receive assistance. Alternatively, an application program could be administered where fire districts apply and demonstrate their need for seismic upgrade funding assistance through fire district-funded seismic evaluation reports, seismic upgrade designs, and benefit-costs analyses.

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8.0 Closing

The School Seismic Safety Project (Phases 1 and 2) has been an incredible opportunity to study and evaluate school buildings across the state and has demonstrated the need for dedicated funding for seismic retrofits. This overall SSSP study delivers on the project objectives of assessing seismically vulnerable school buildings, prioritizing this building data for the benefit of the state, and providing seismic screening reports for the school districts; all in an effort of taking an important step towards improving the seismic safety of 561 school buildings and 7 fire stations in Washington.

This study however has only screened approximately 12 percent of the stock of permanent school buildings and there are over 2,500 buildings in the ICOS database that were built earlier than 1980, about 75 percent of which are located in the high seismic areas west of the Cascades. There are many other older and seismically vulnerable school buildings in the state that still need attention.

Although mitigating all of the state's oldest school buildings right away may not be possible or financially feasible, especially considering other safety hazards and immediate facility needs for schools, incremental steps are being taken to increase the seismic safety of our schools. Washington's policy makers, school districts, and design professionals are actively turning seismic knowledge into action. This needs to continue to happen year to year, and more aggressively so, to be able to get through the state's inventory of older school buildings. At the local level, many school districts and communities are able to pass levies and bonds to replace or significantly modernize their older school buildings. However, there are some school districts who have not been able to do so and may need the state's assistance to do so.

At the state level, a School Seismic Safety Retrofit Grant Program, the first of its kind in Washington State, was created in 2020 and is underway in seismically upgrading select school buildings. The project team applauds and further encourages the state for continued funding dedicated to school seismic safety retrofits through this grant program. Our hope is that with continued funding at the state level, in combination with local community funding and federal funding, seismic safety of school buildings can be mitigated equitably across the state, save lives, and make for a more seismic resilient Washington.

The cost of inaction on seismic safety is too great for our children, parents, teachers, and our communities. And although we have taken strides in earthquake awareness and preparedness, there is still a great deal more to be done. Washingtonians, through further awareness and support of their communities and school districts, can provide the necessary investments needed for improving seismic safety and our community infrastructure across the state.

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APPENDIX B.1: SEISMIC SCREENING DATA FIGURES

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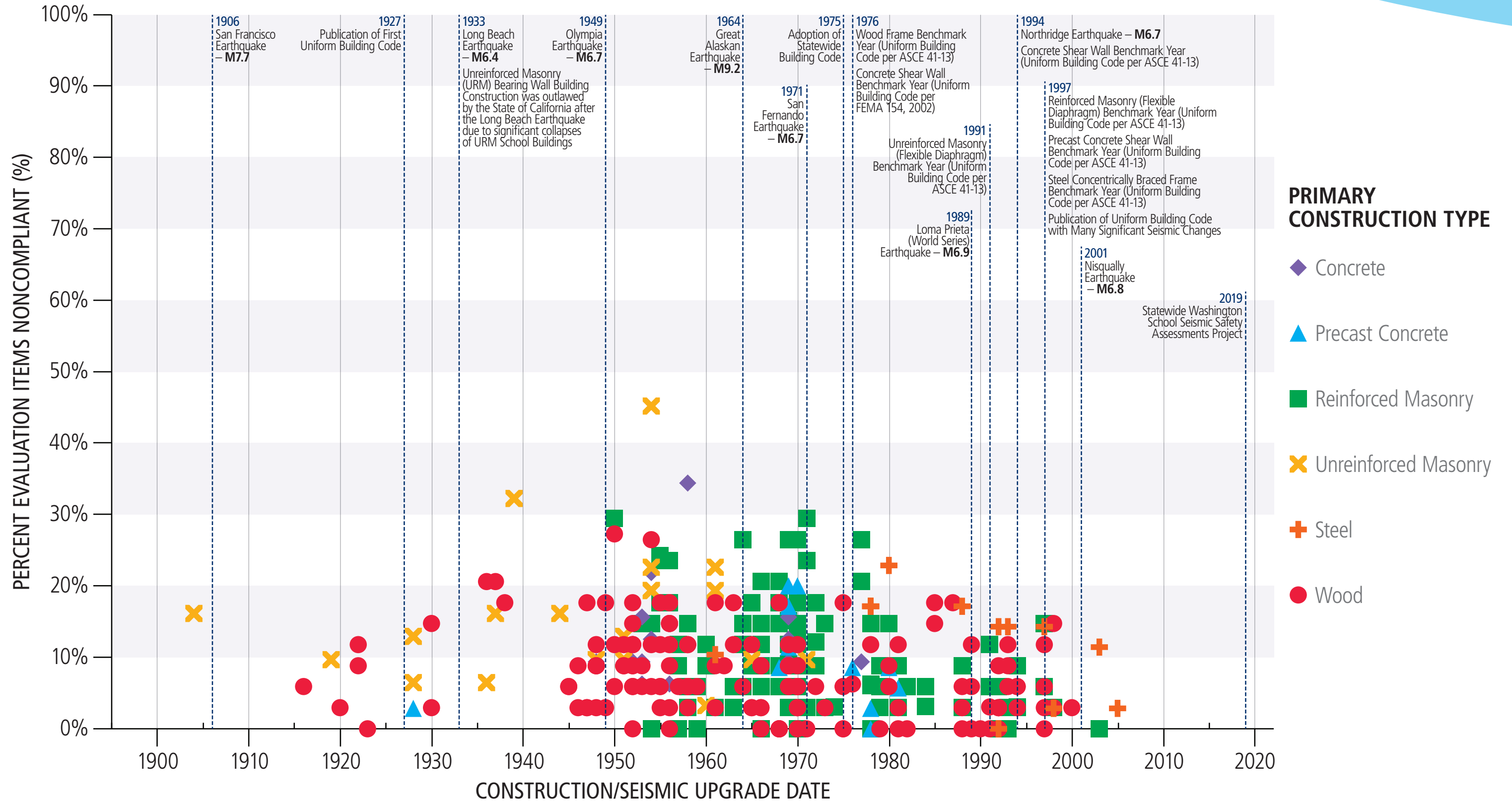


Figure B.1-1 – Phase 2 – ASCE 41 Tier 1 Percent Evaluation Items Noncompliant Categorized by Primary Construction Type

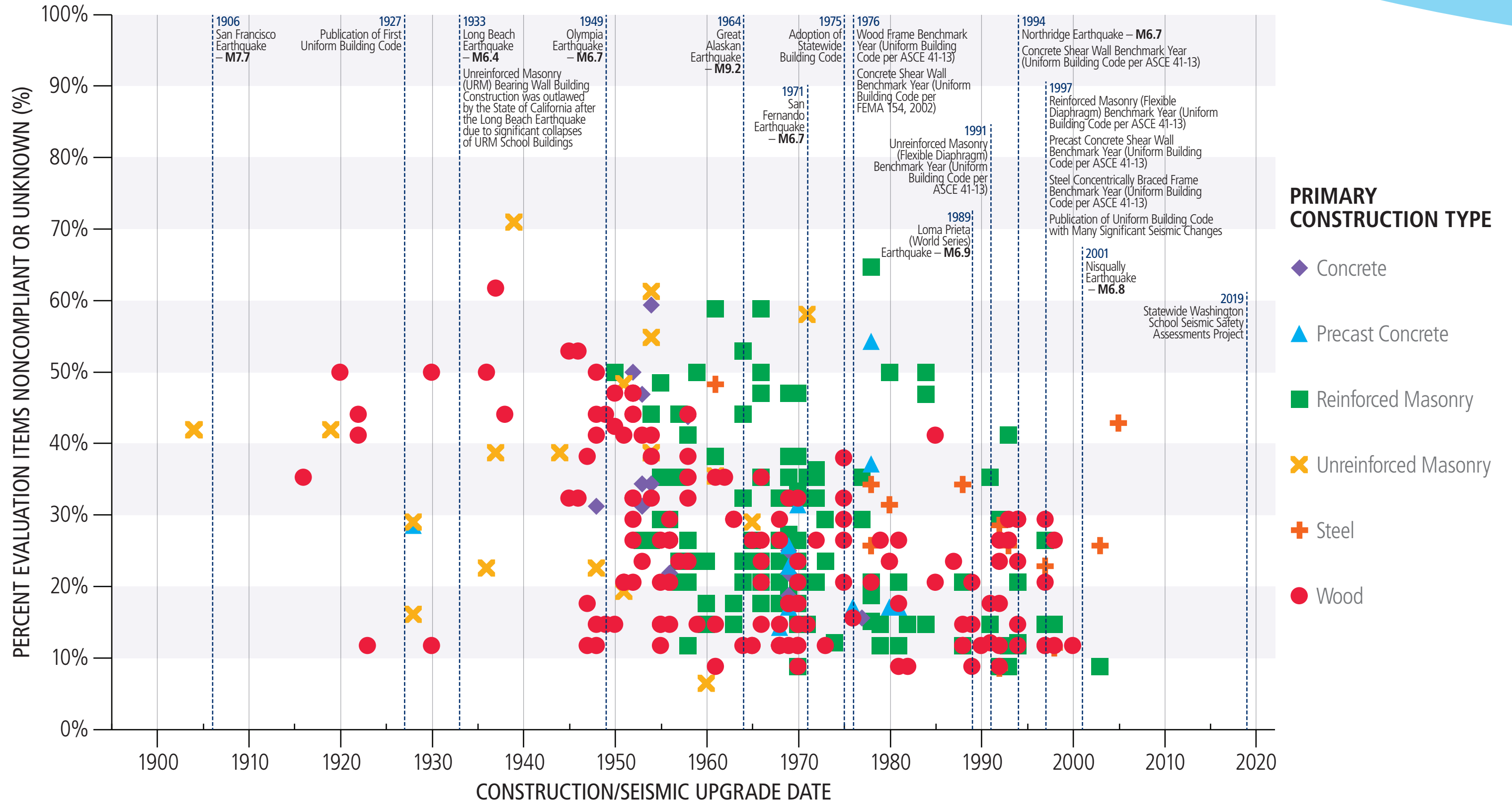
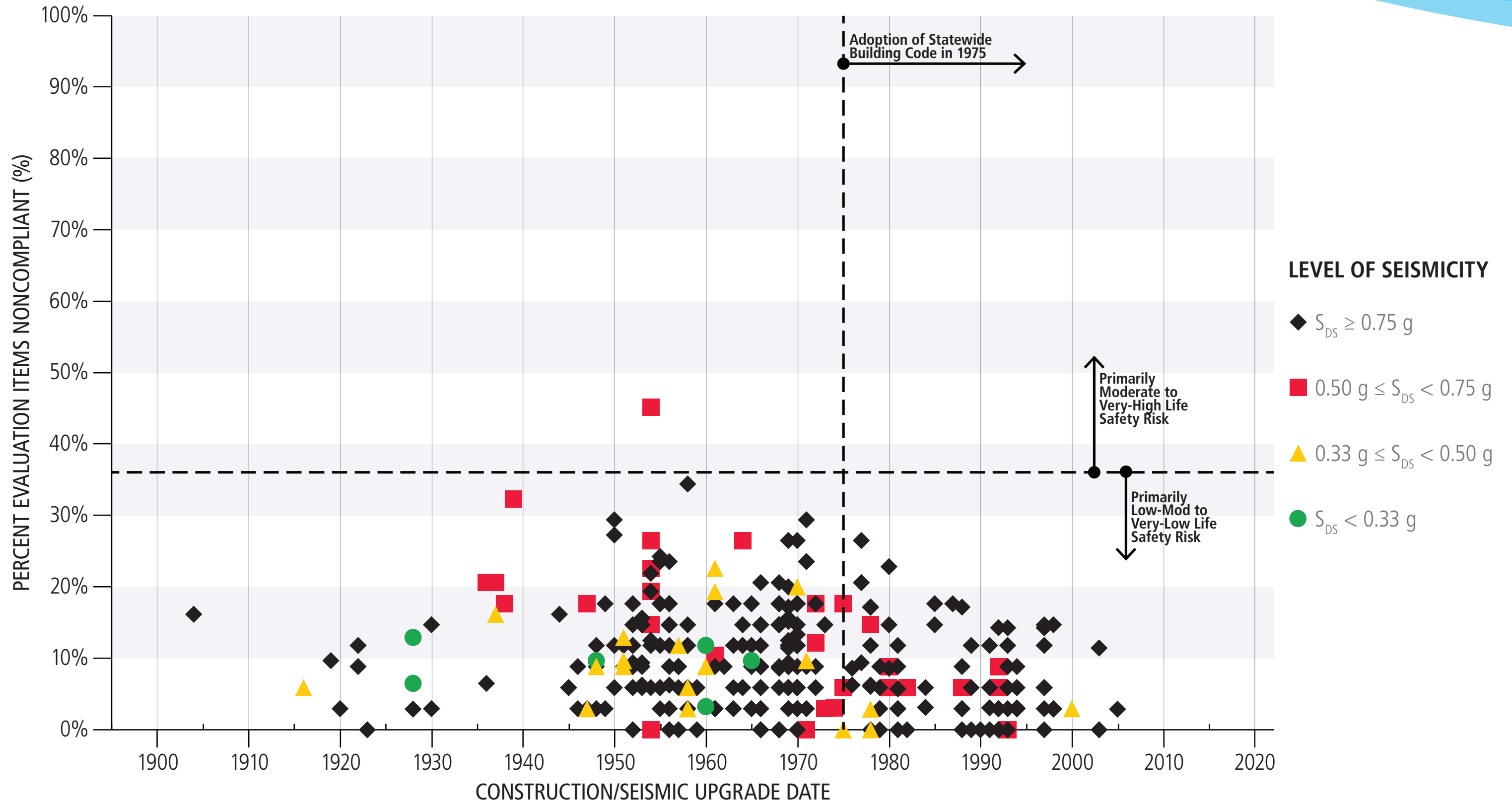


Figure B.1-2 – Phase 2 – ASCE 41 Tier 1 Percent Evaluation Items Noncompliant Or Unknown Categorized By Primary Construction Type



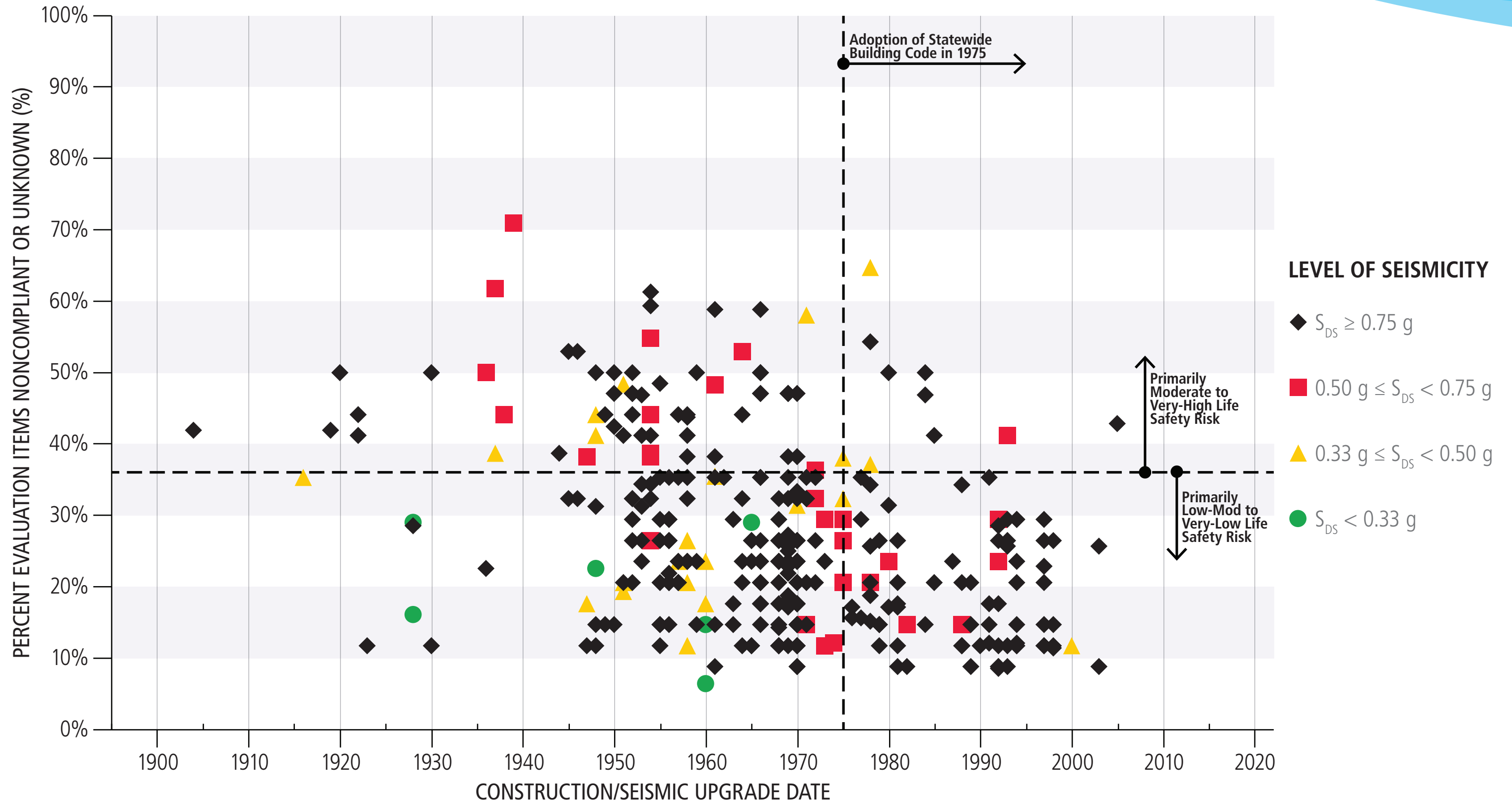
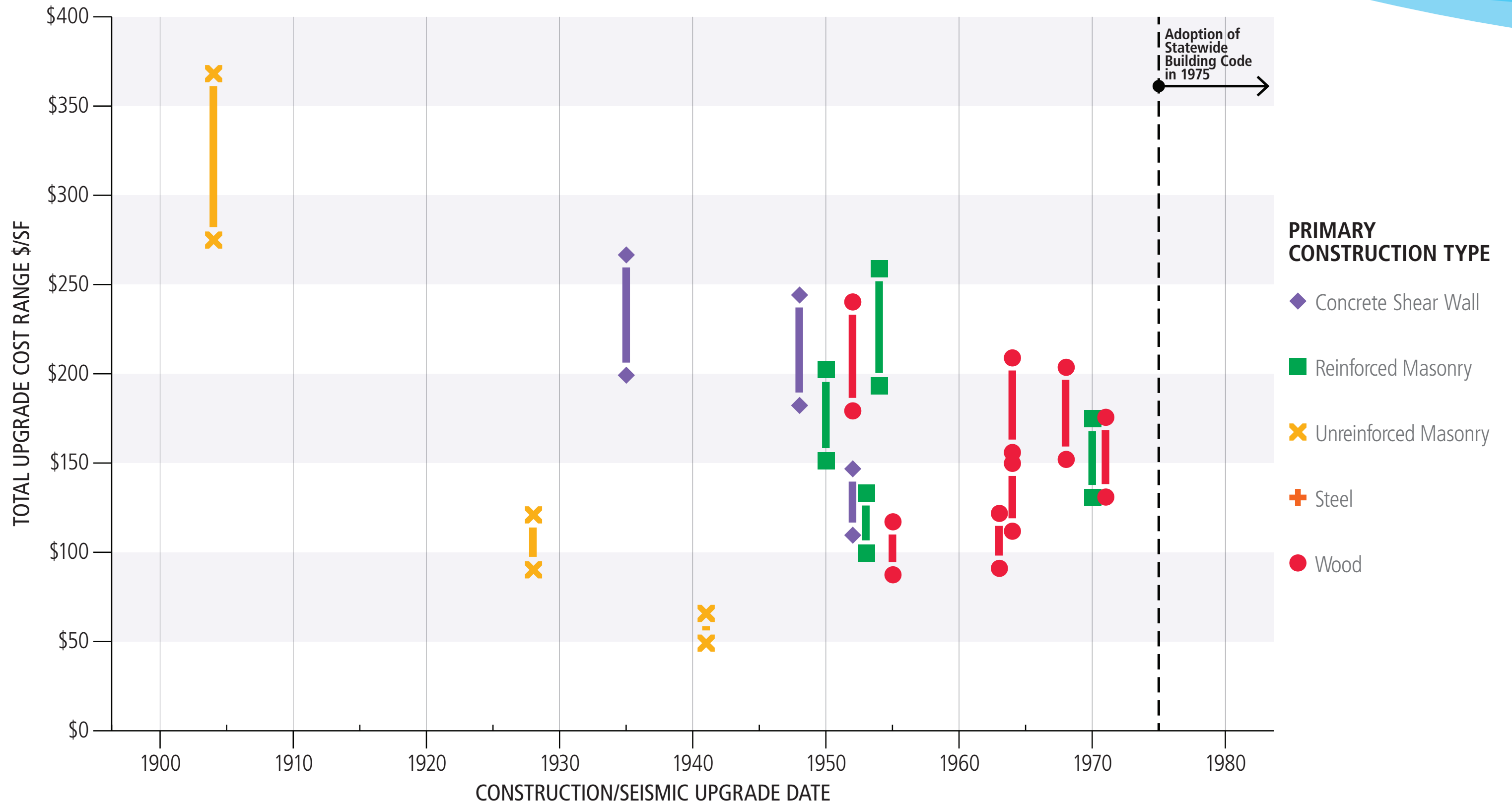
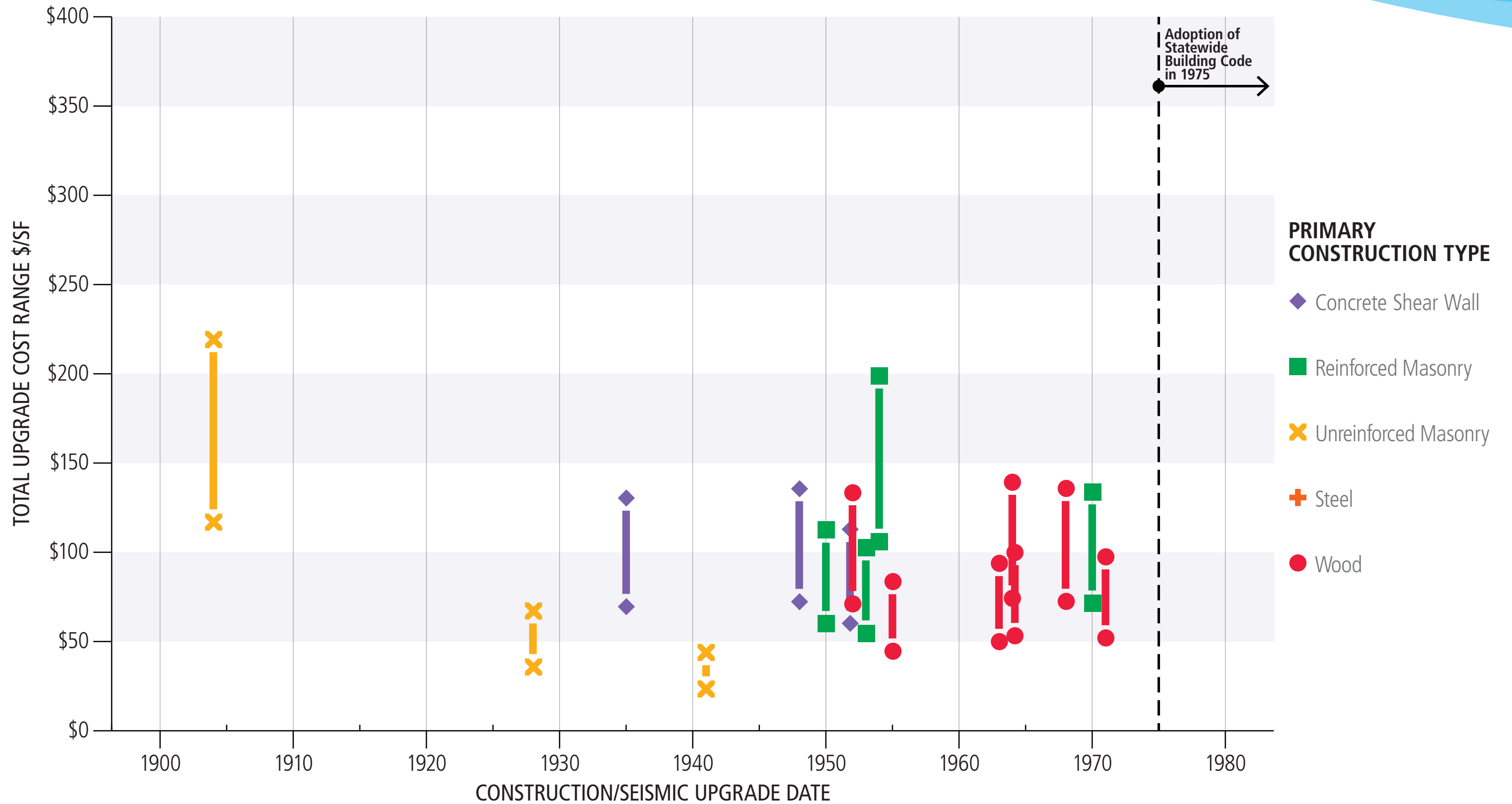
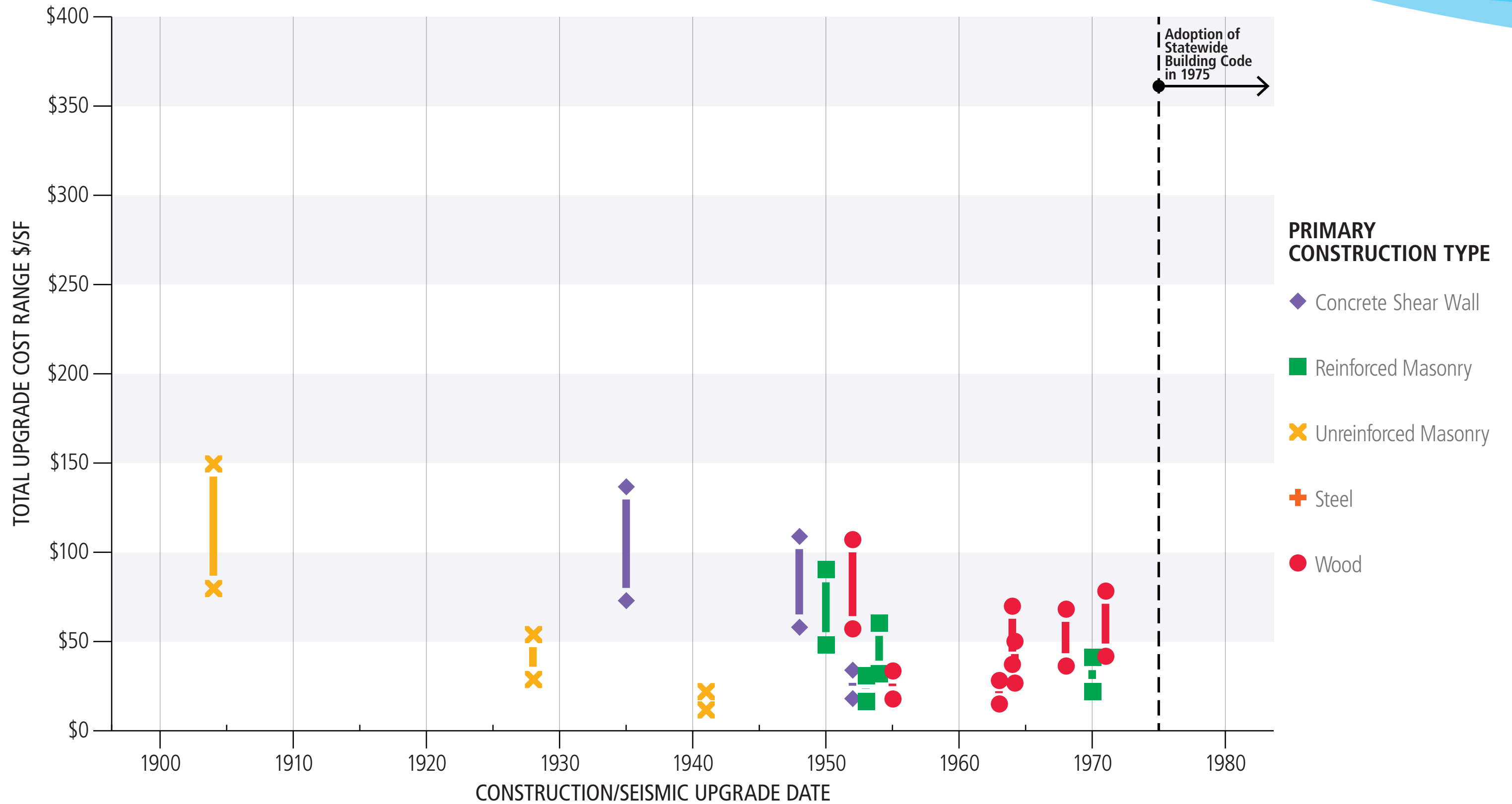
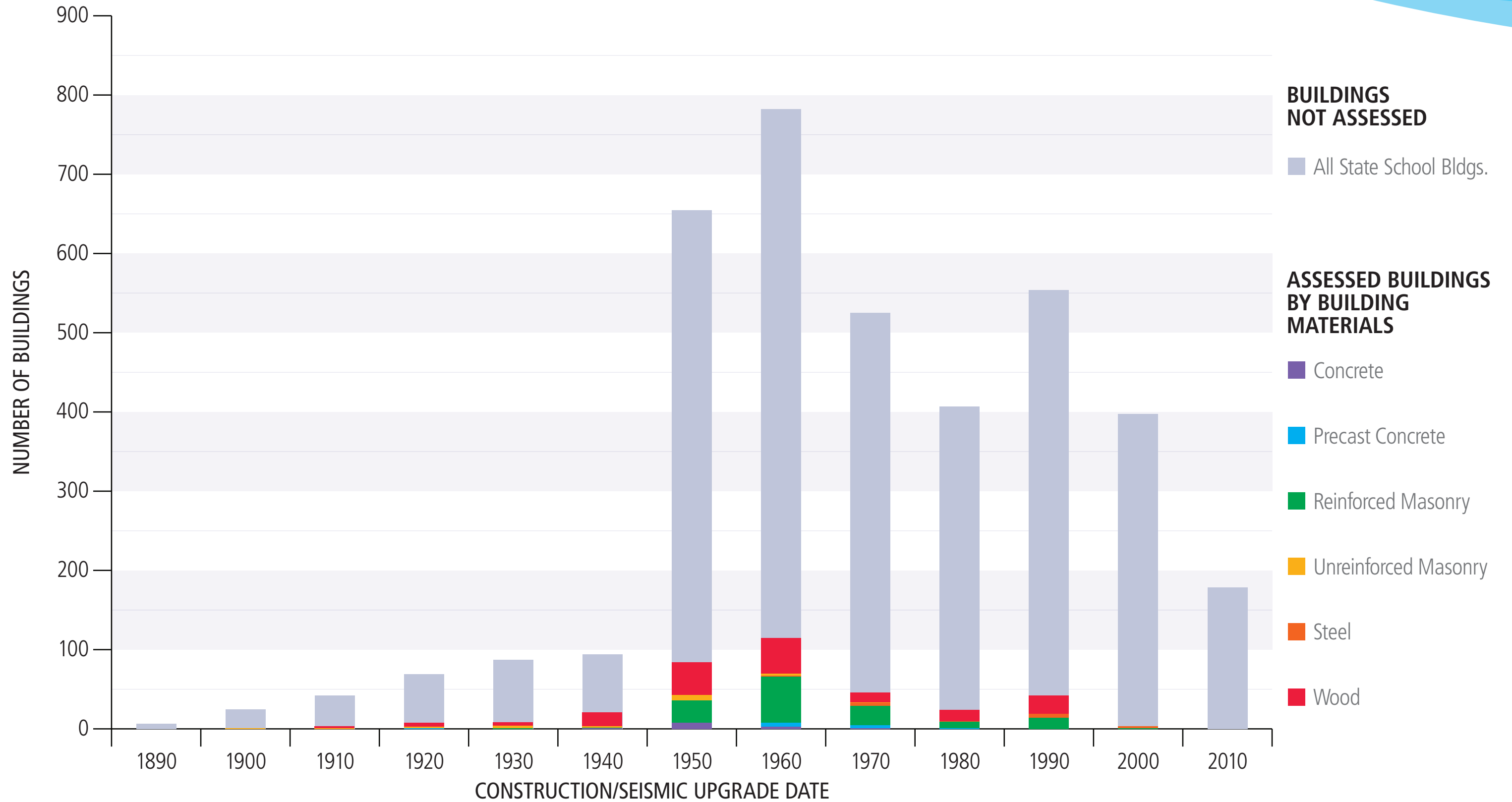


Figure B.1-4 – Phase 2 – ASCE 41 Tier 1 Percent Evaluation Items Noncompliant or Unknown Categorized by Short-Period Spectral Acceleration (S_{DS})









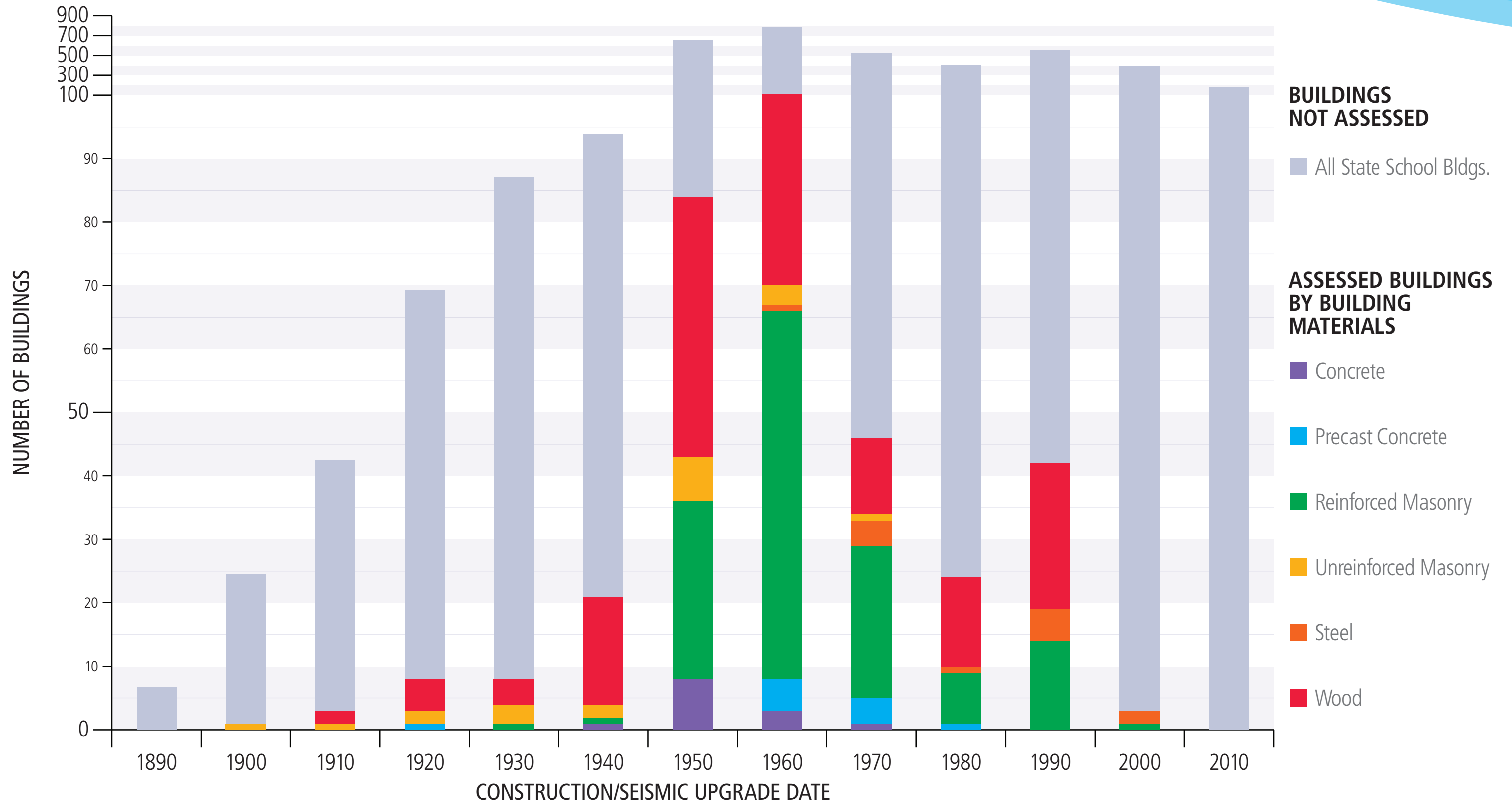


Figure B.1-9 – Phase 2 – Quantity of WA School Buildings Categorized by Construction Decade & Primary Construction Type of Buildings Assessed

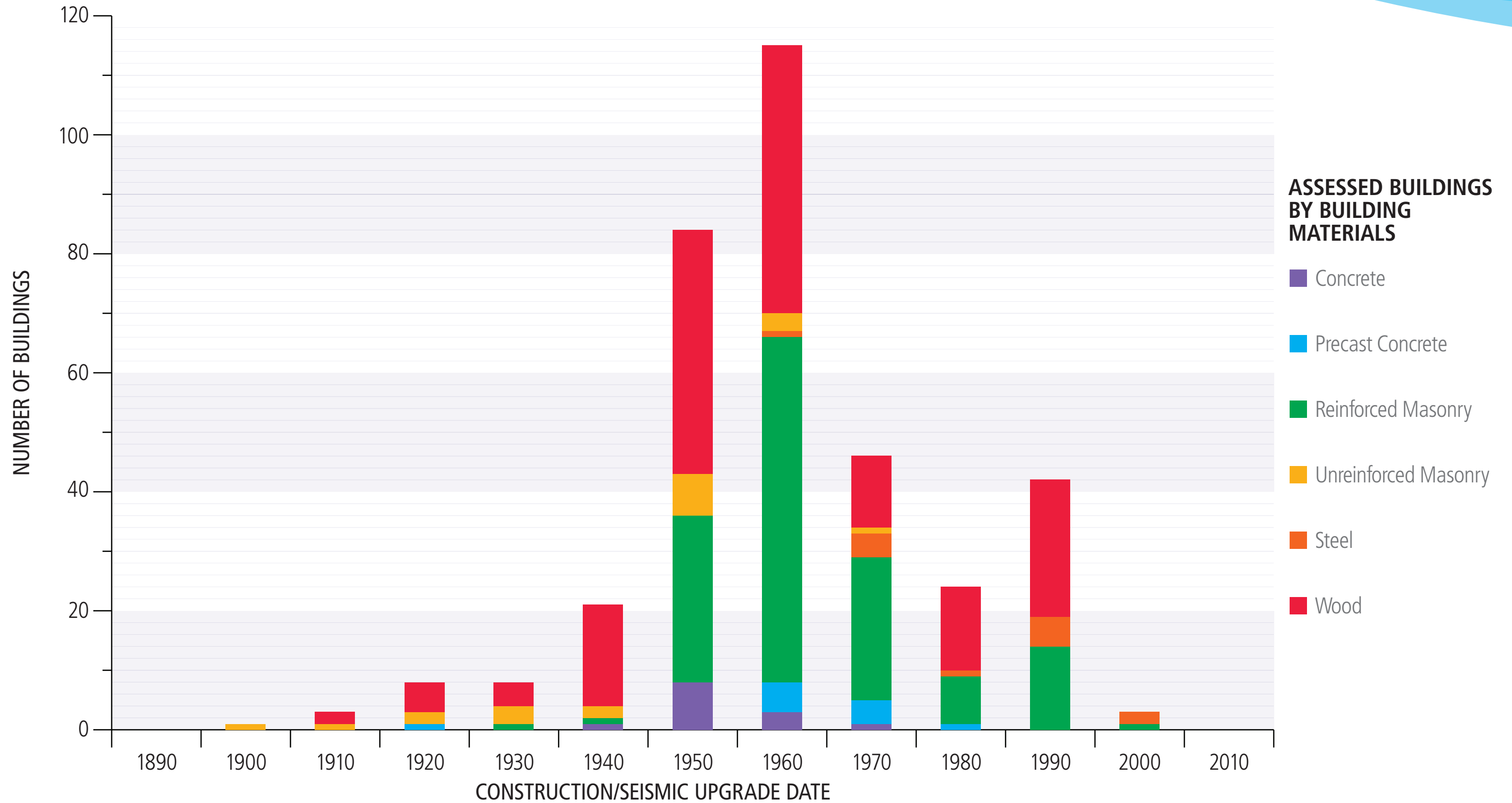


Figure B.1-10 – Phase 2 – Quantity of WA School Buildings Categorized by Construction Decade & Primary Construction Type of Buildings Assessed

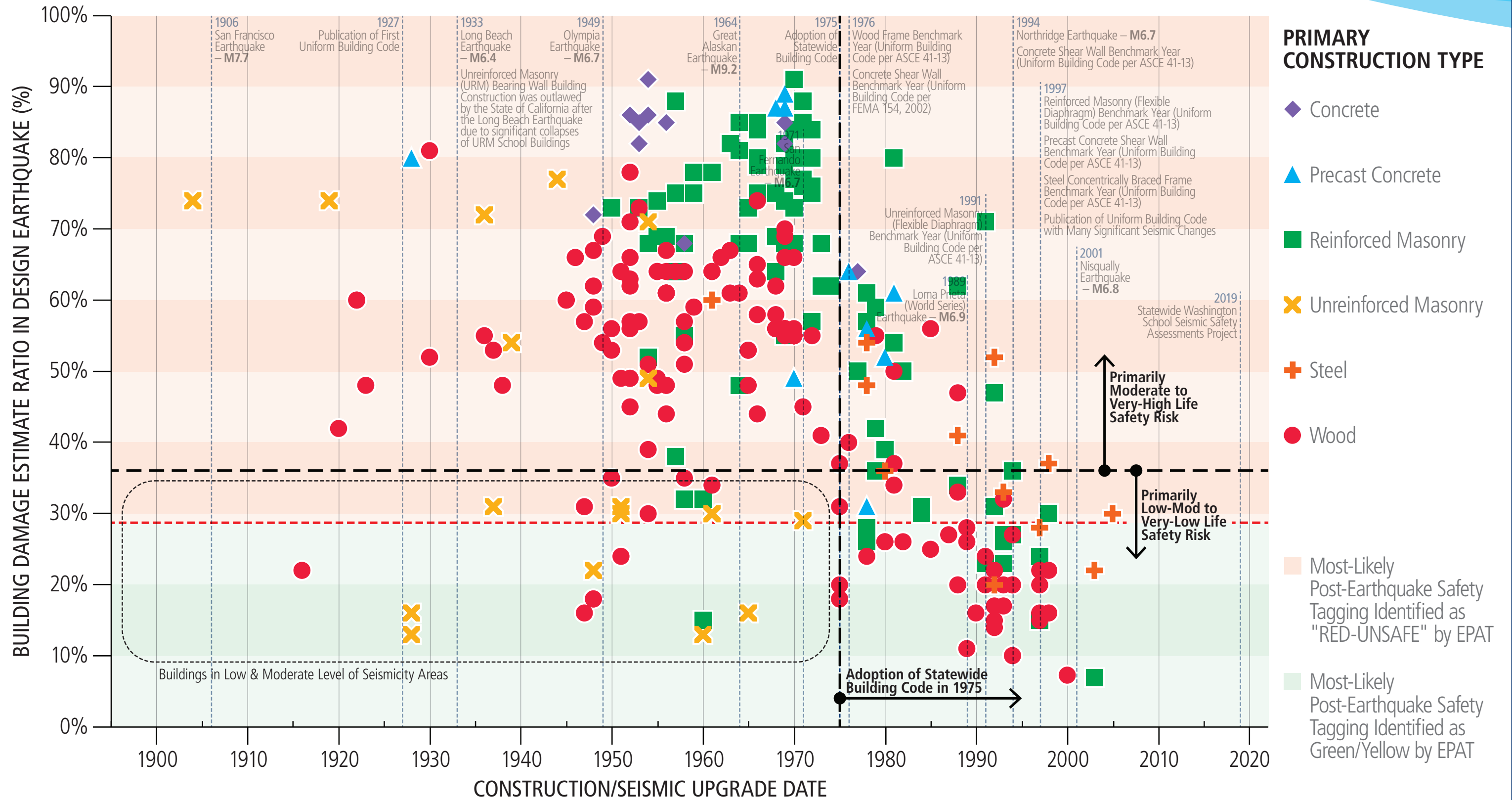
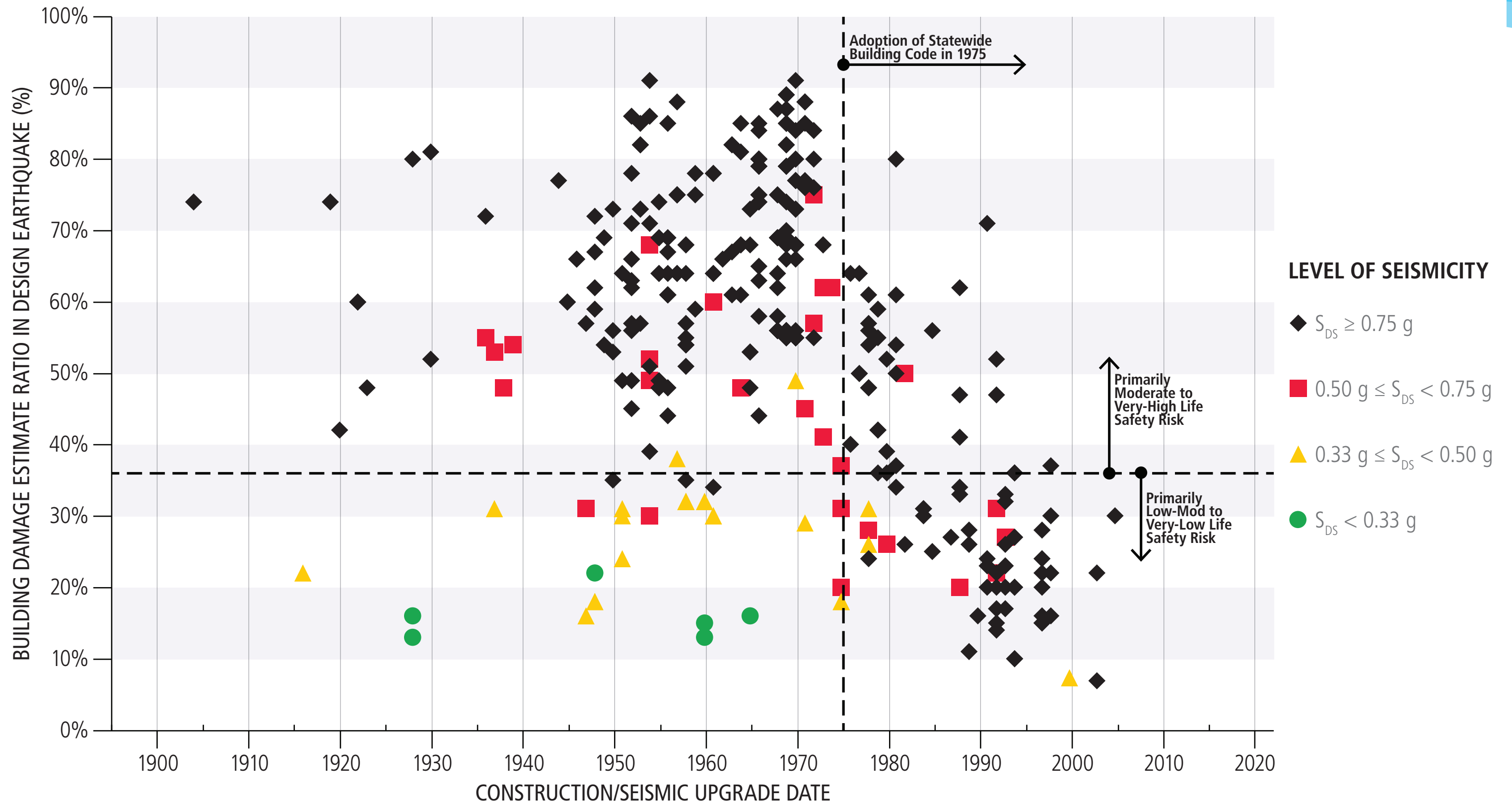
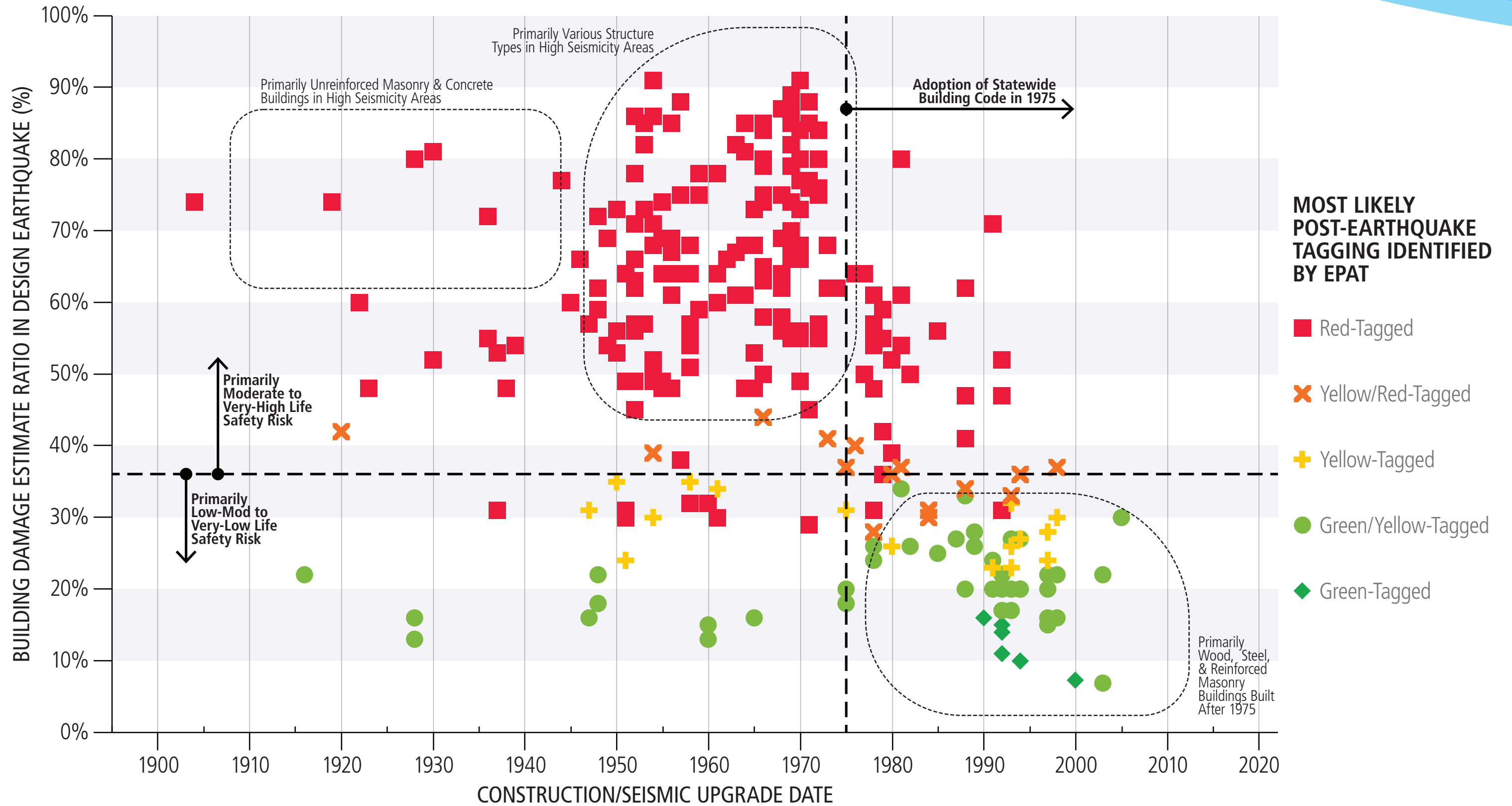
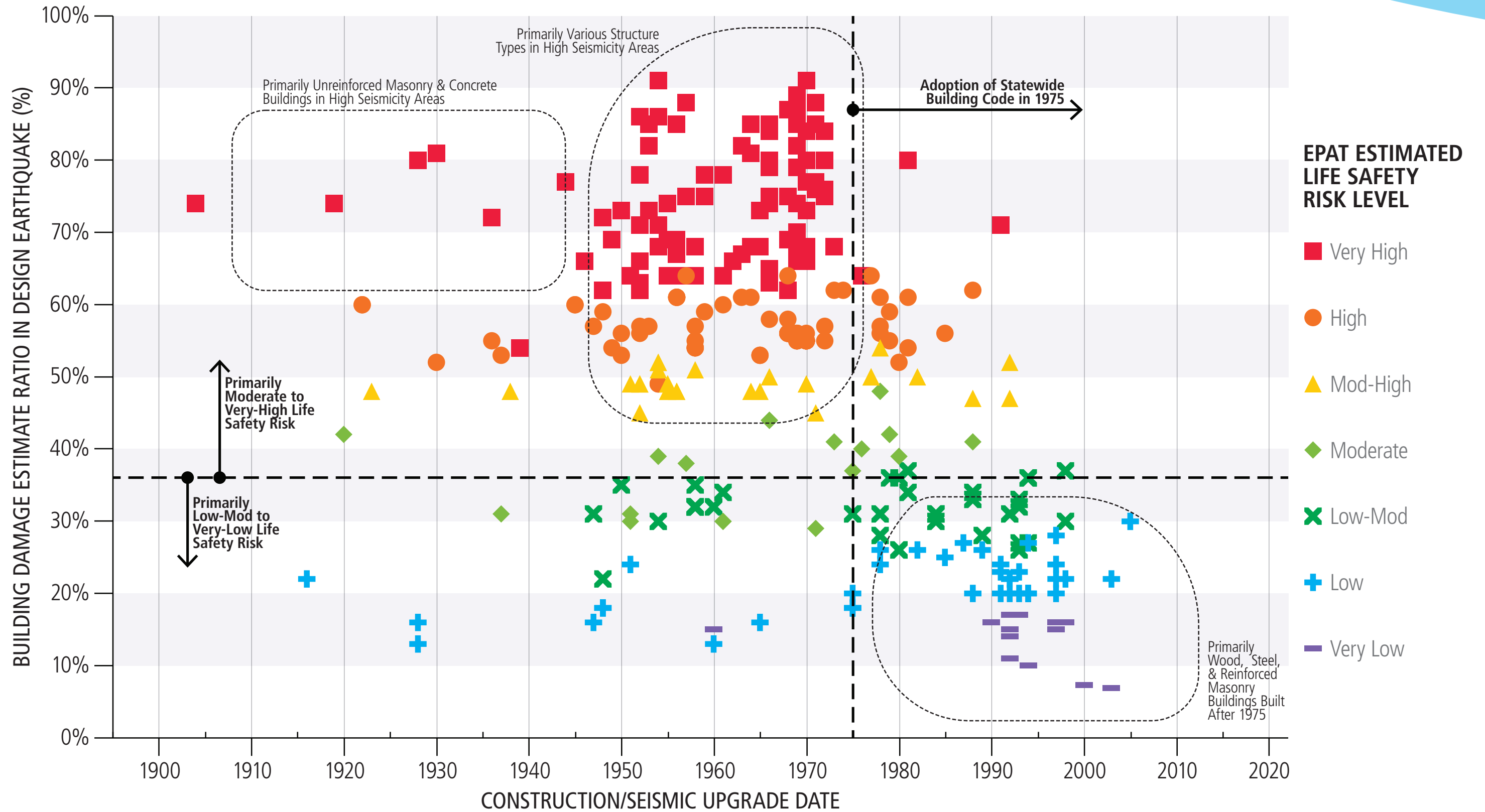


Figure B.1-11 – Phase 2 – EPAT Building Damage Estimate Ratio in ASCE 7/41 Design-Level Earthquake Categorized by Primary Construction Type







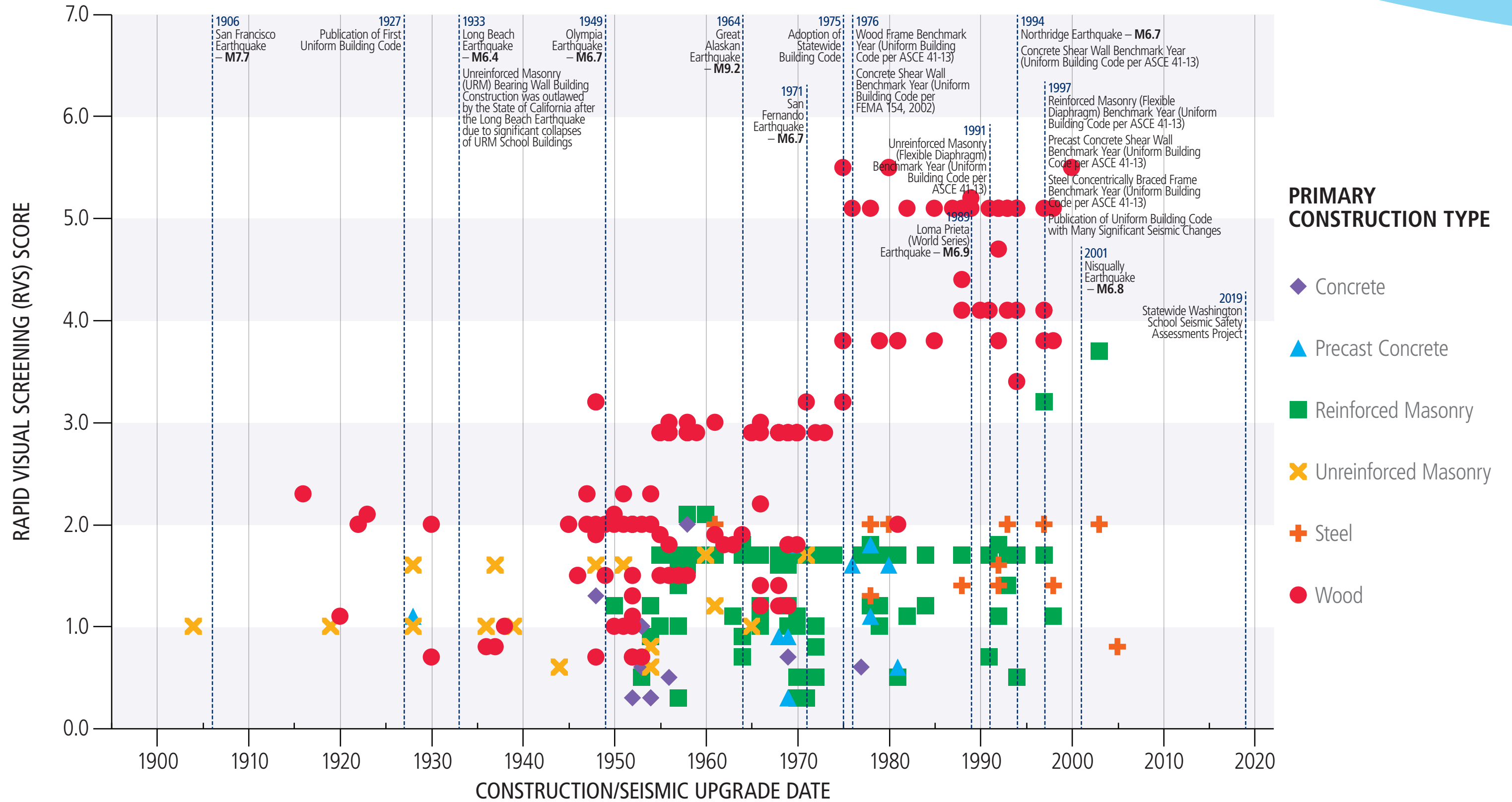


Figure B.1-15 – Phase 2 – FEMA 154 Rapid Visual Screening (RVS) Score Categorized by Primary Construction Type

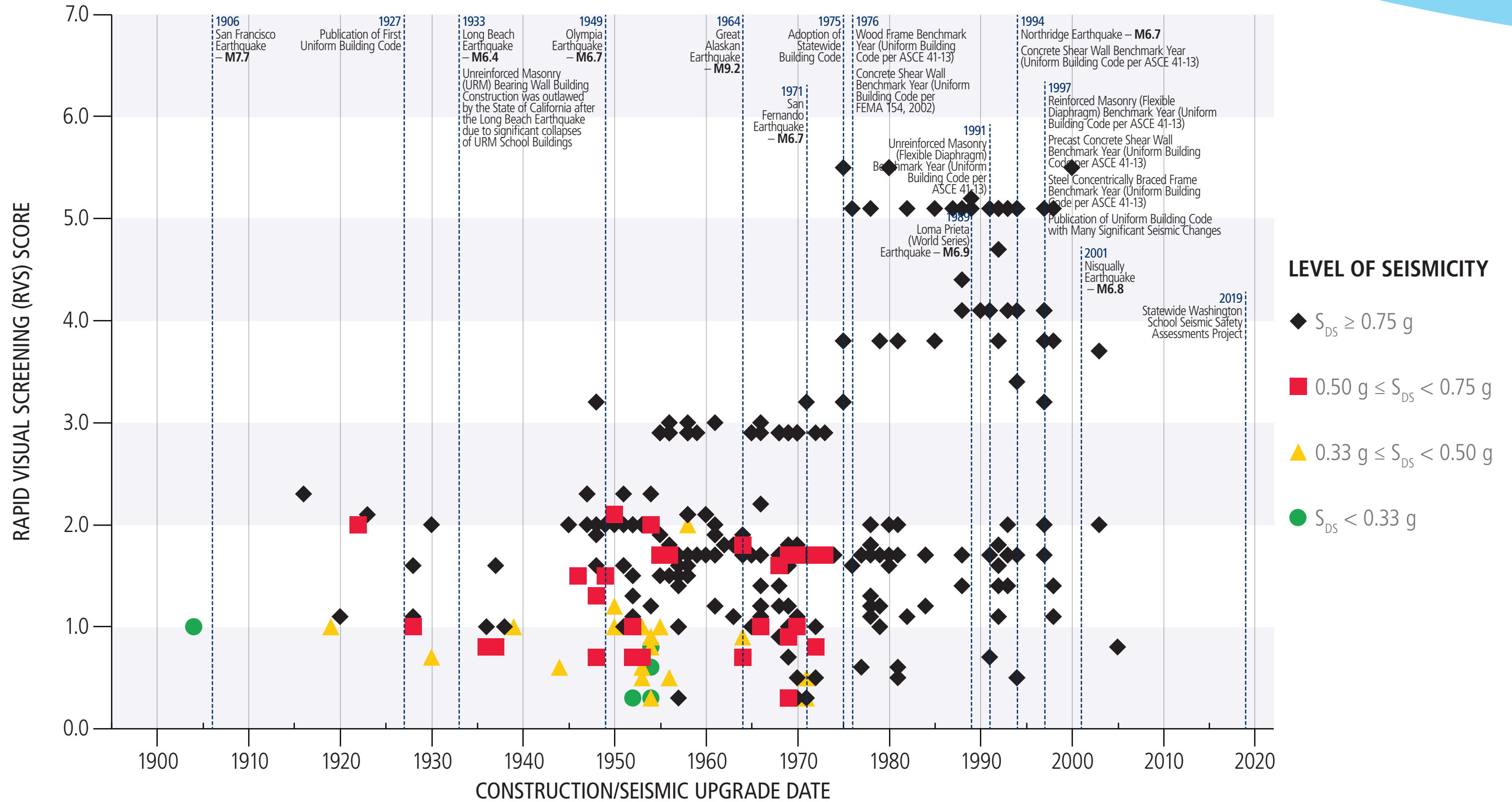


Figure B.1-16 – Phase 2 – FEMA 154 Rapid Visual Screening (RVS) Score Categorized by Short-Period Spectral Acceleration (S_{DS})

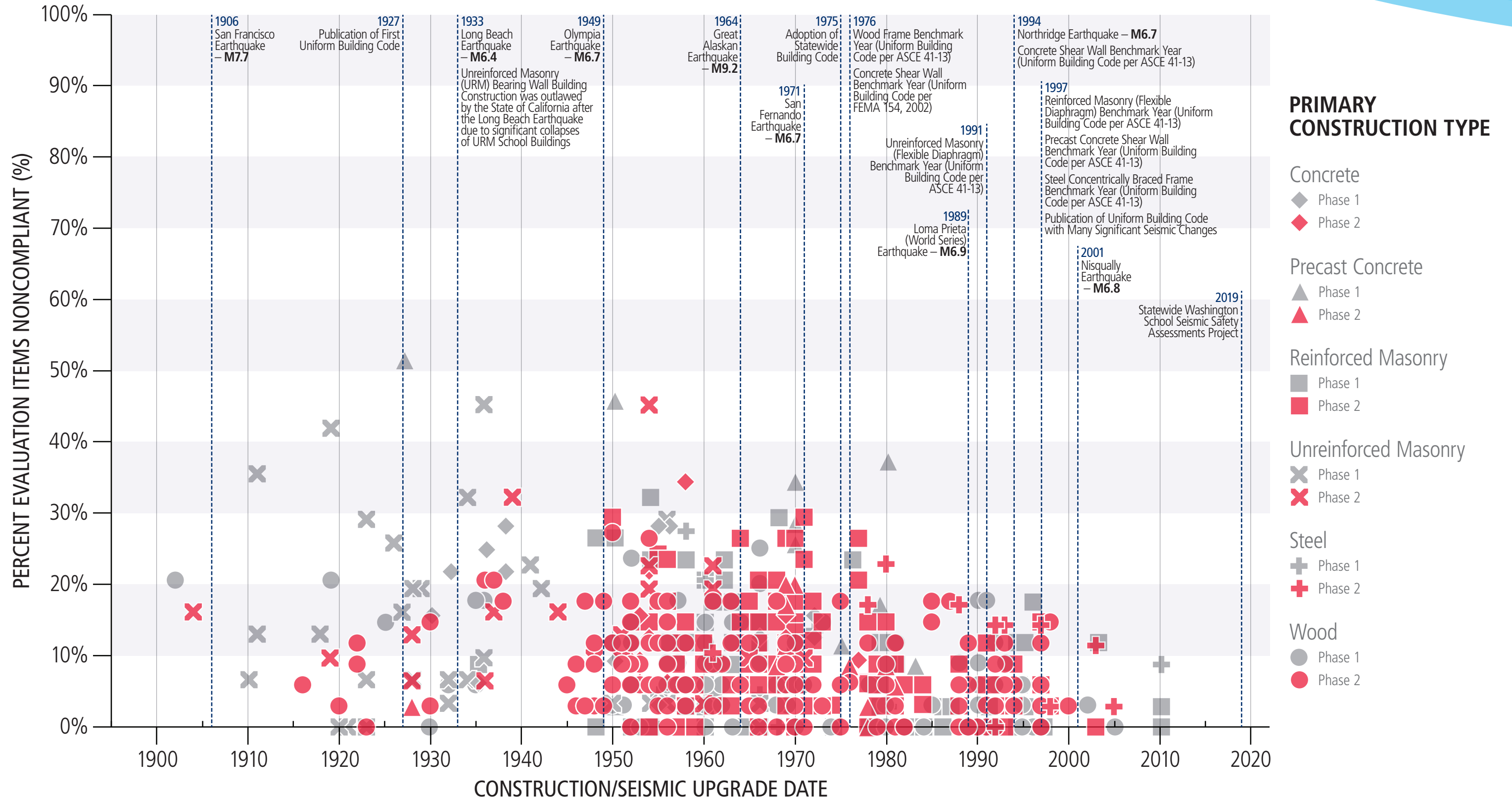


Figure B.1-17 – Phase 1 & Phase 2 – FEMA 154 Rapid Visual Screening (RVS) Score Categorized by Short-Period Spectral Acceleration (S_{DS})

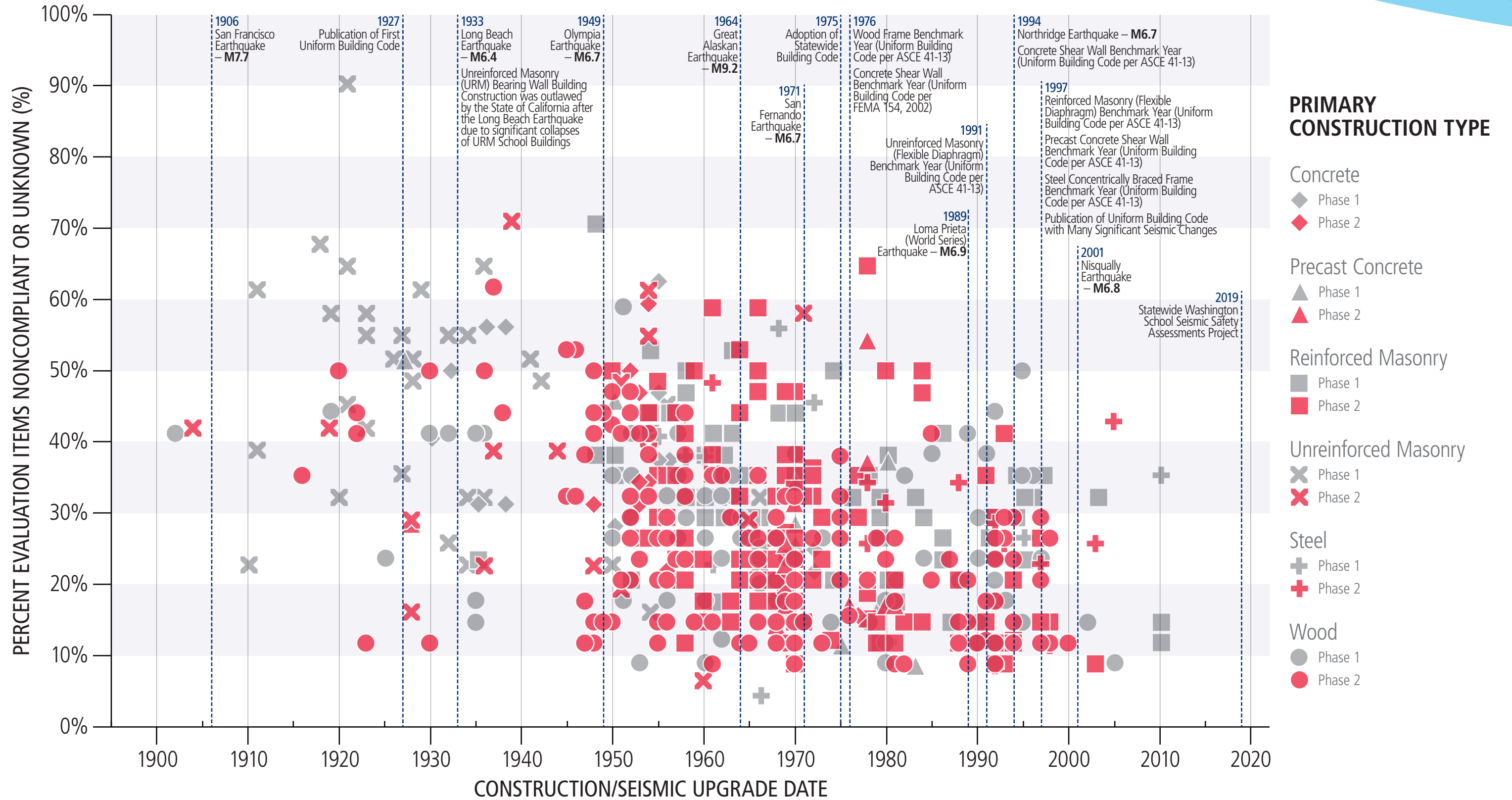


Figure B.1-18 – Phase 1 & Phase 2 – ASCE 41 Tier 1 Percent Evaluation Items Noncompliant Or Unknown Categorized By Primary Construction Type

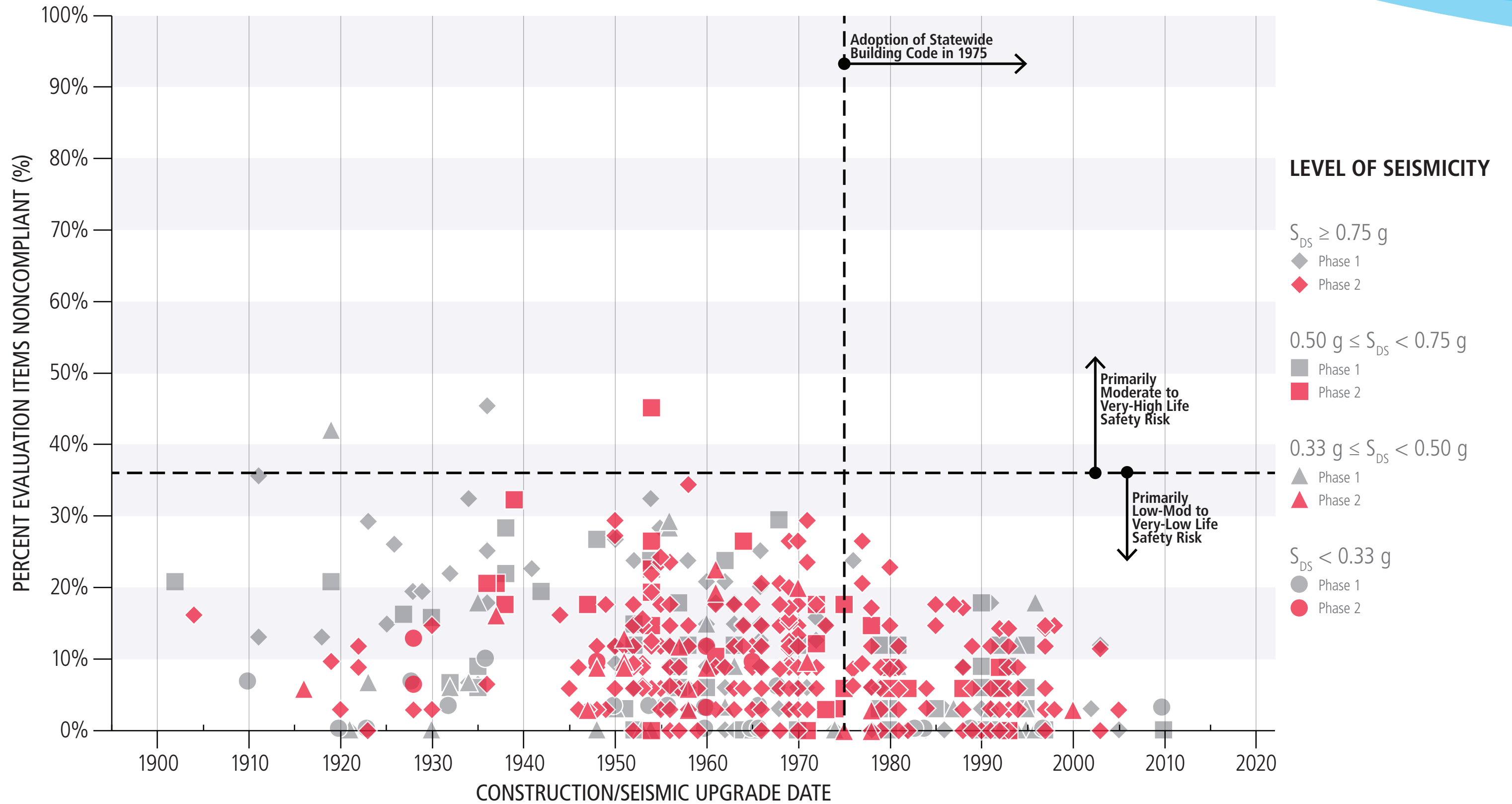


Figure B.1-19 – Phase 1 & Phase 2 – ASCE 41 Tier 1 Percent Evaluation Items Noncompliant Categorized by Short-Period Spectral Acceleration (S_{DS})

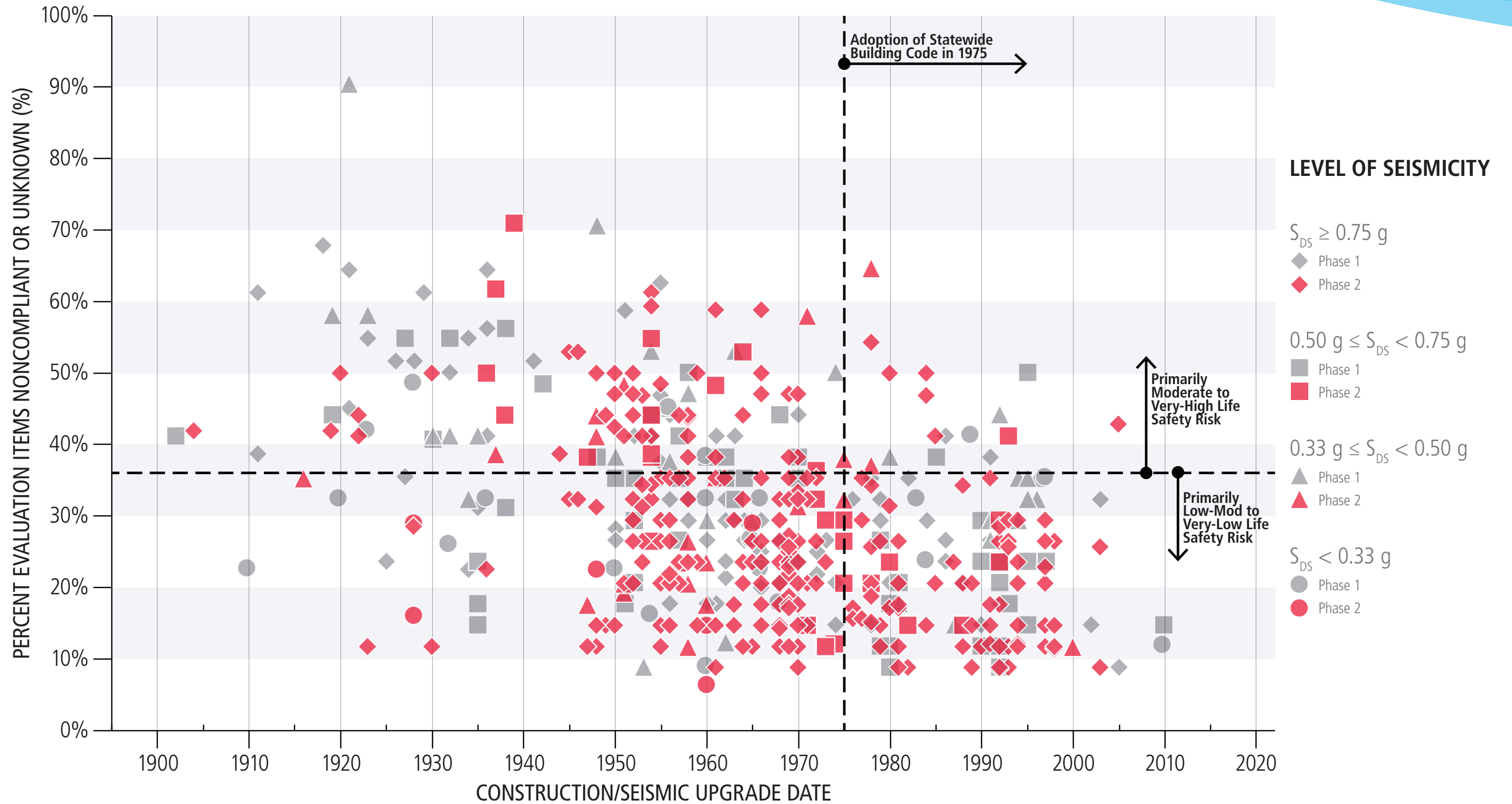
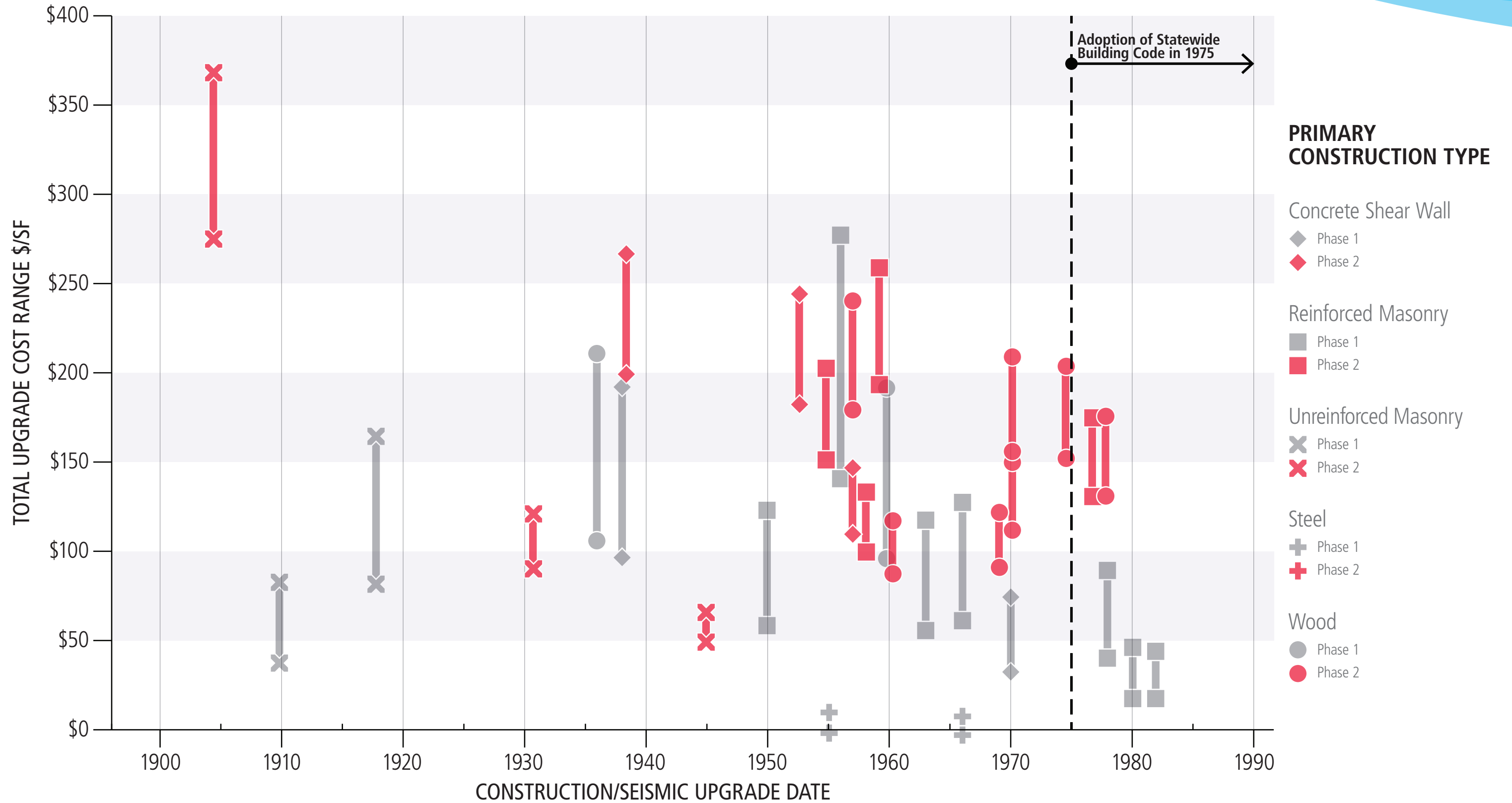
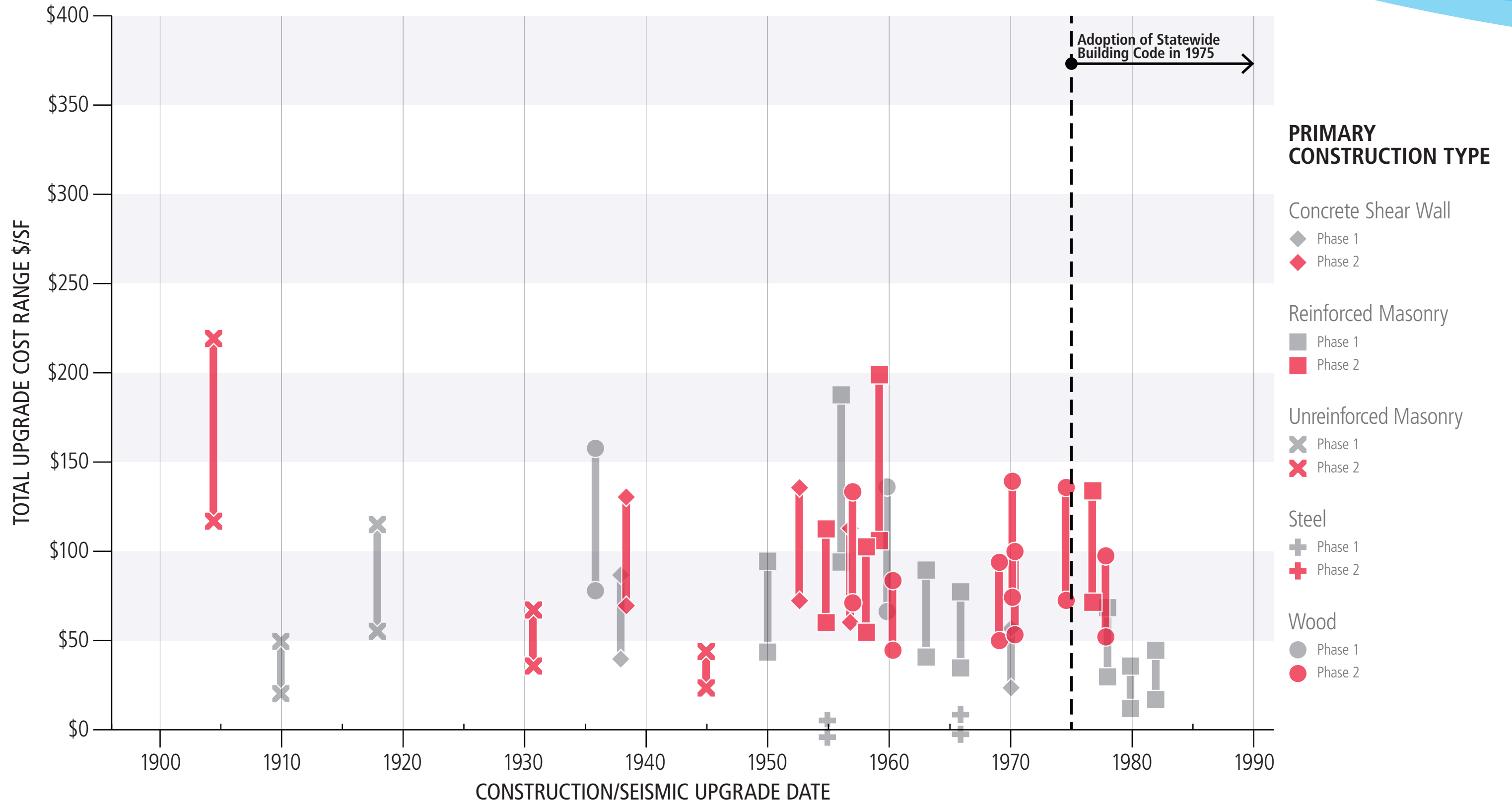
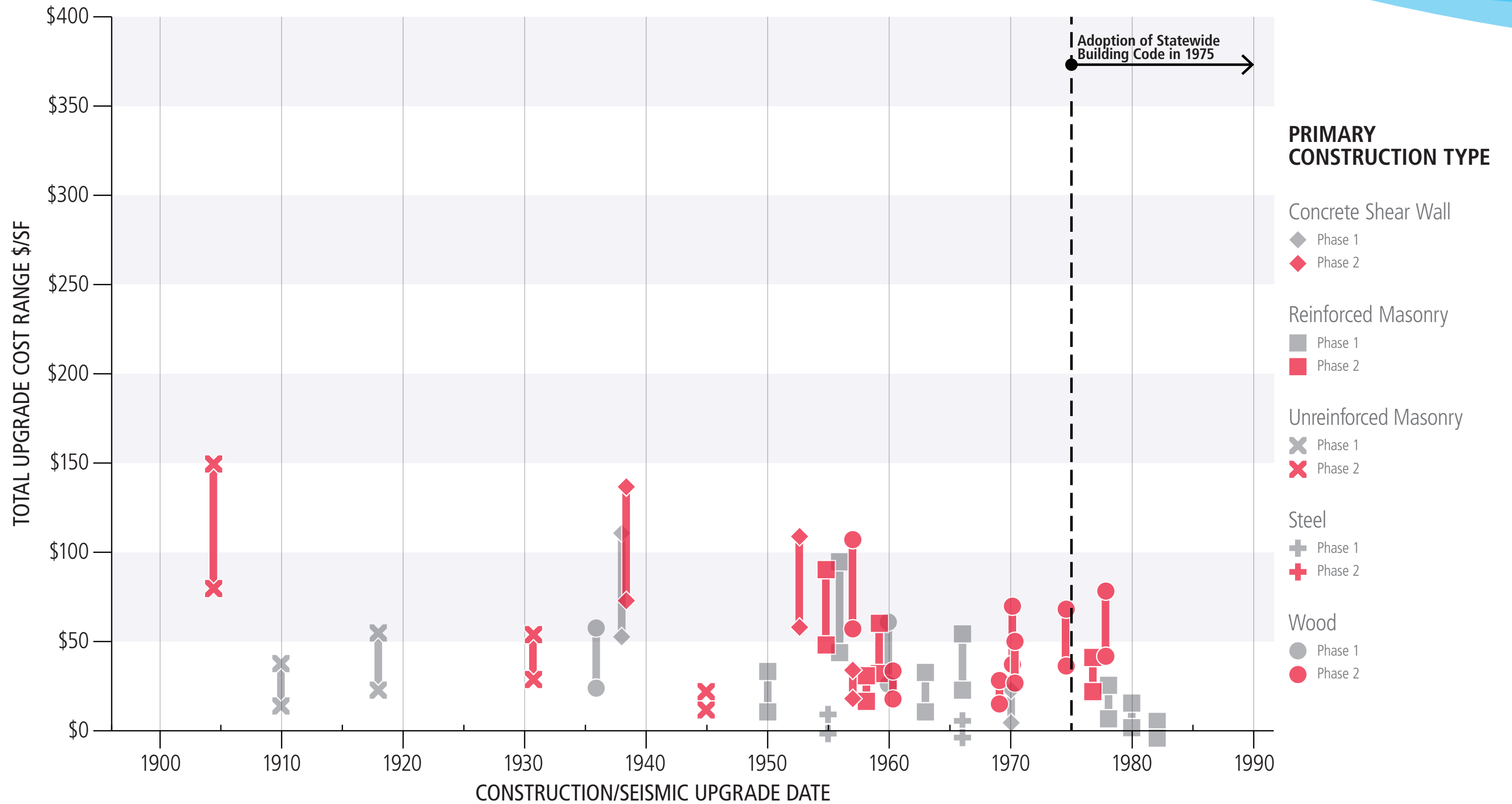


Figure B.1-20 – Phase 1 & Phase 2 – ASCE 41 Tier 1 Percent Evaluation Items Noncompliant or Unknown Categorized by Short-Period Spectral Acceleration (S_{DS})







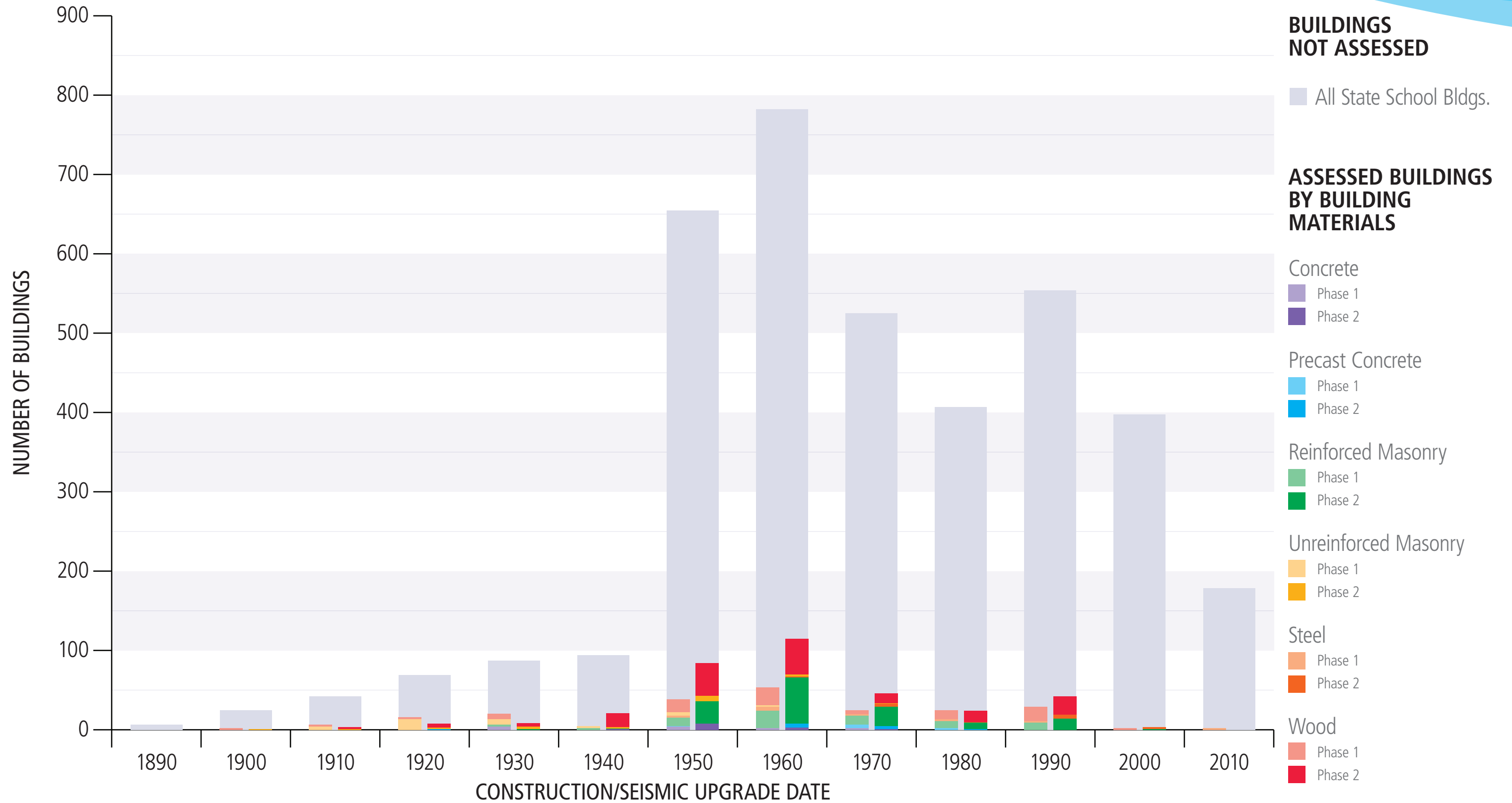


Figure B.1-24 – Phase 1 & Phase 2 – Quantity of WA School Buildings Categorized by Construction Decade & Primary Construction Type of Buildings Assessed

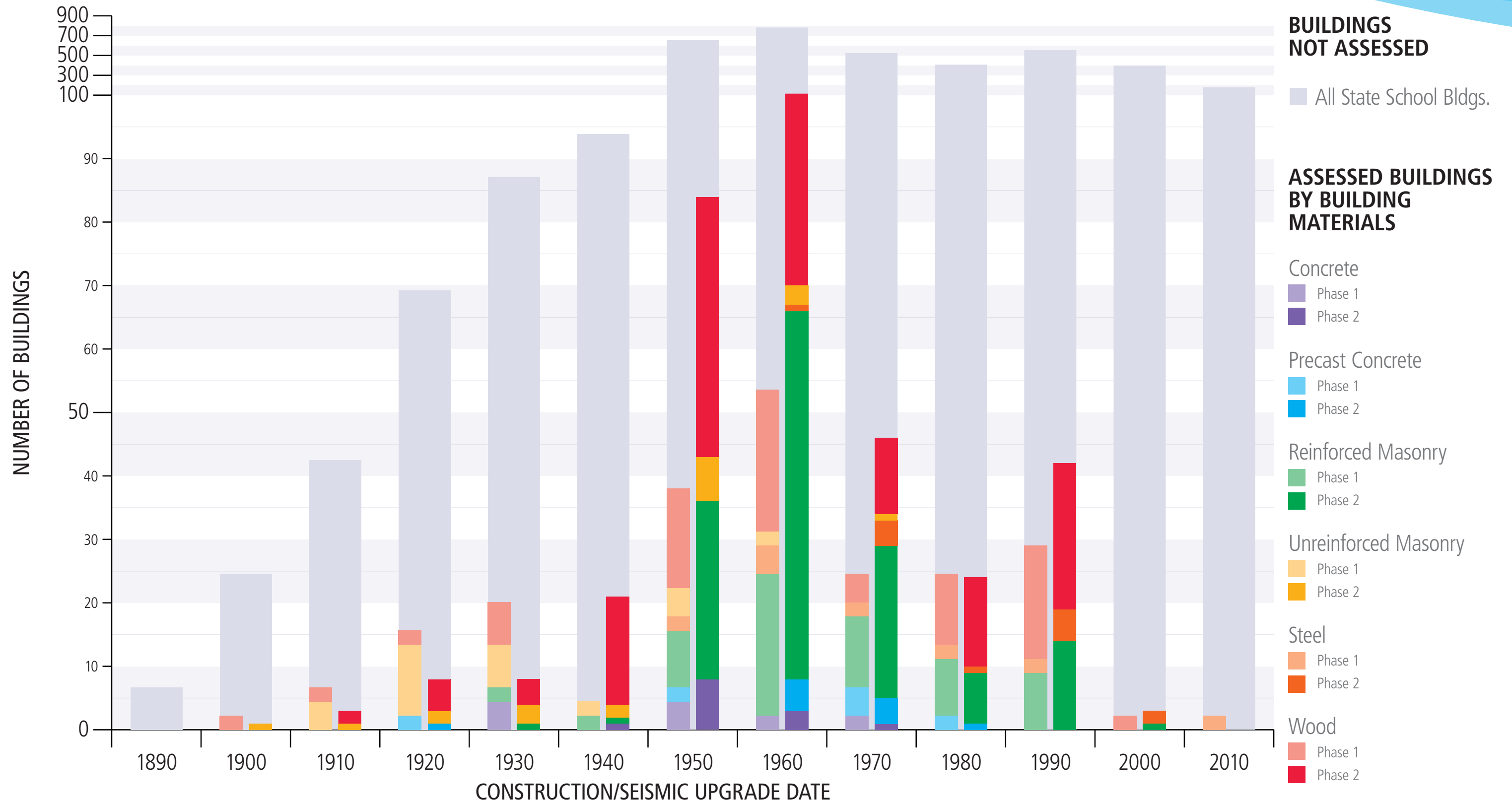


Figure B.1-25 – Phase 1 & Phase 2 – Quantity of WA School Buildings Categorized by Construction Decade & Primary Construction Type of Buildings Assessed

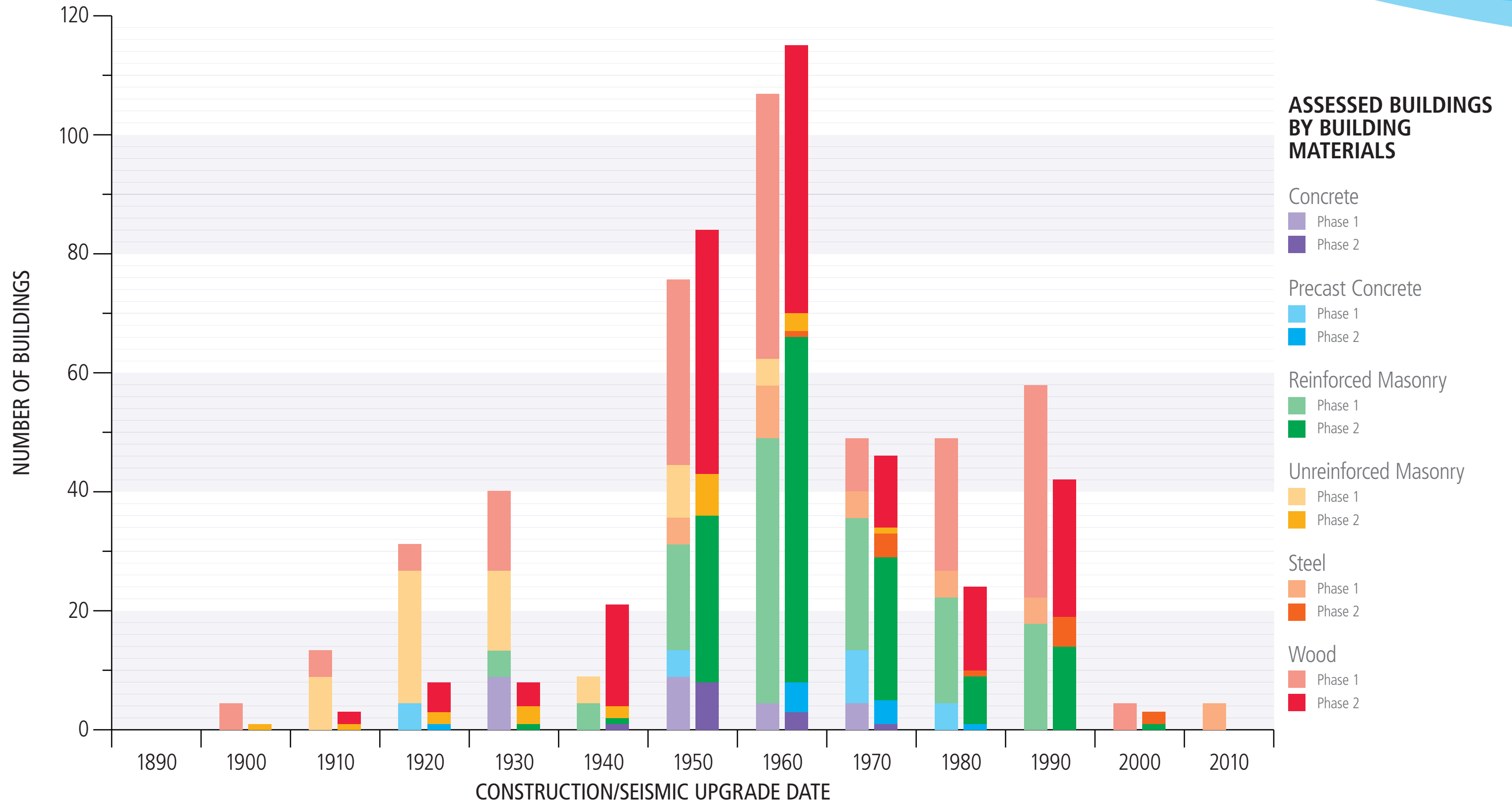


Figure B.1-26 – Phase 1 & Phase 2 – Quantity of WA School Buildings Categorized by Construction Decade & Primary Construction Type of Buildings Assessed

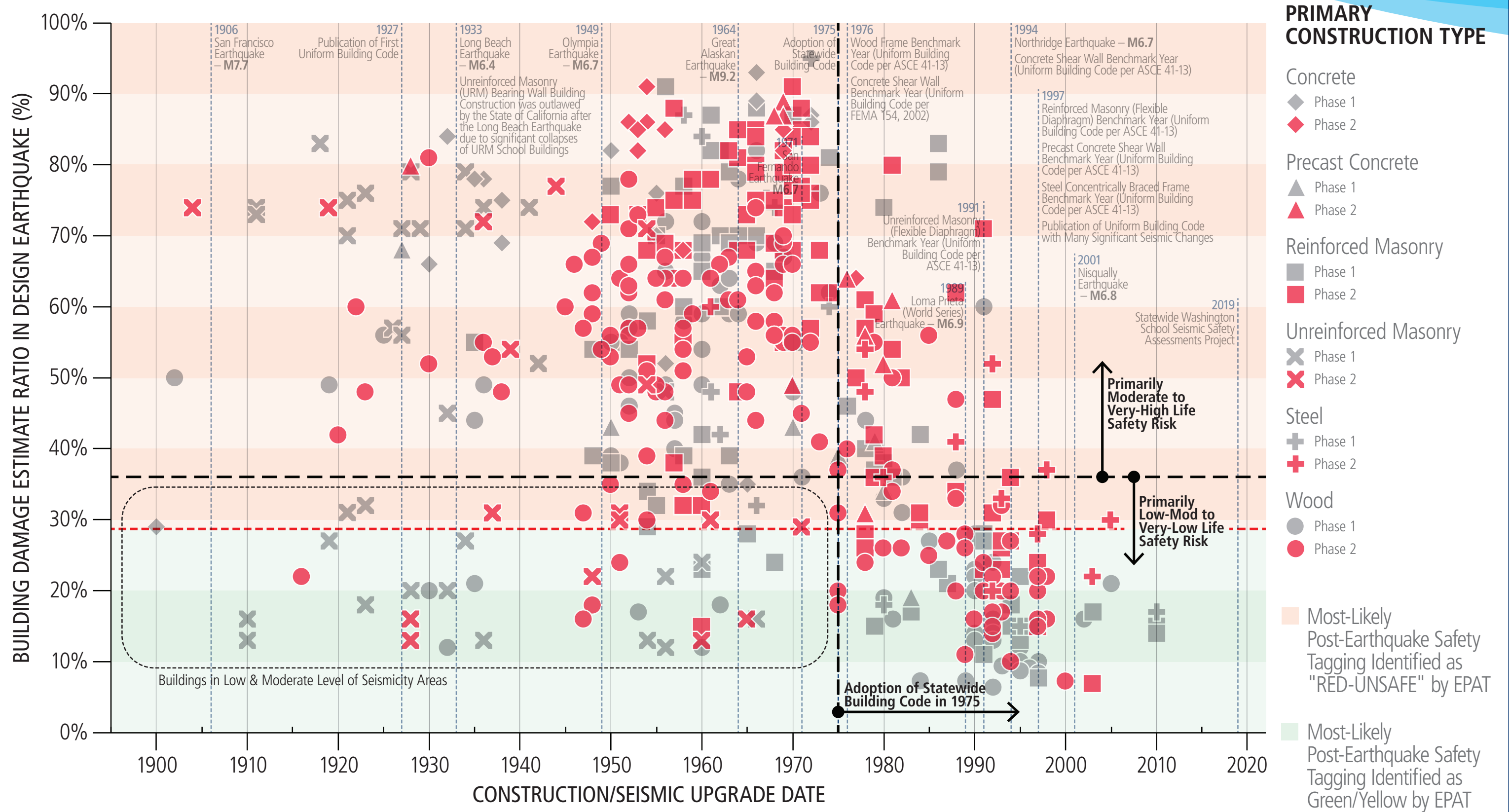
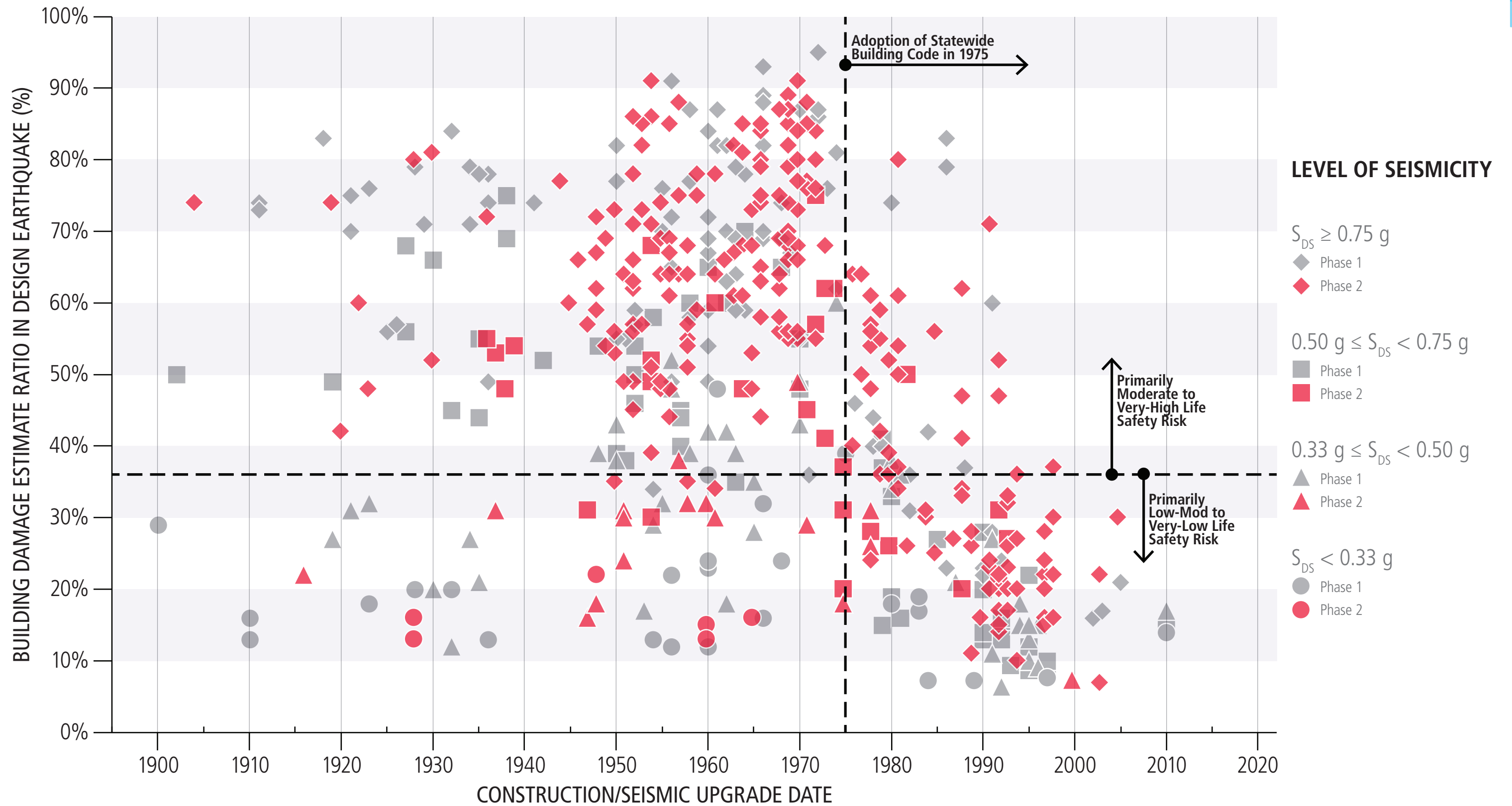


Figure B.1-27 – Phase 1 & Phase 2 – EPAT Building Damage Estimate Ratio in ASCE 7/41 Design-Level Earthquake Categorized by Primary Construction Type



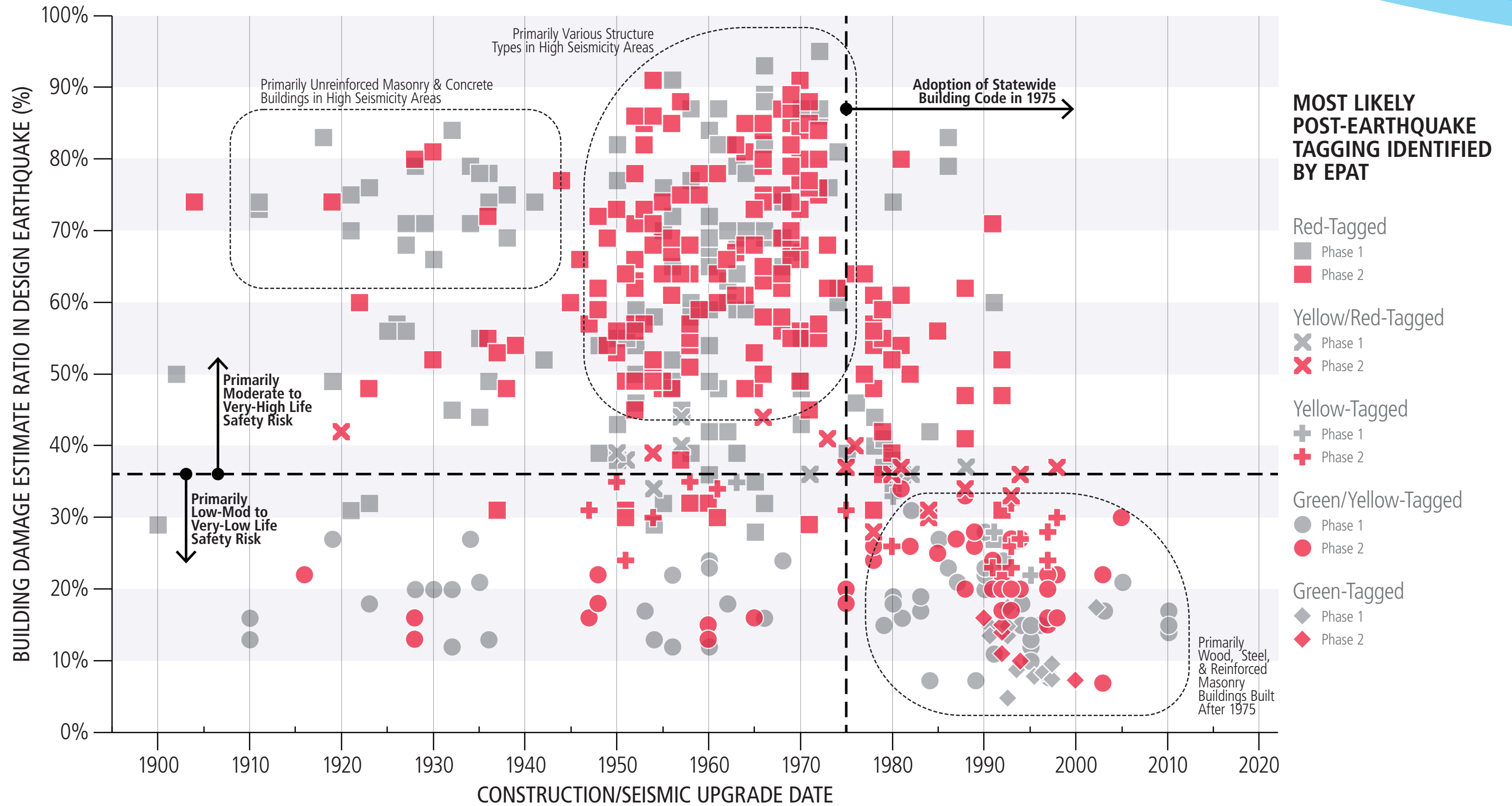
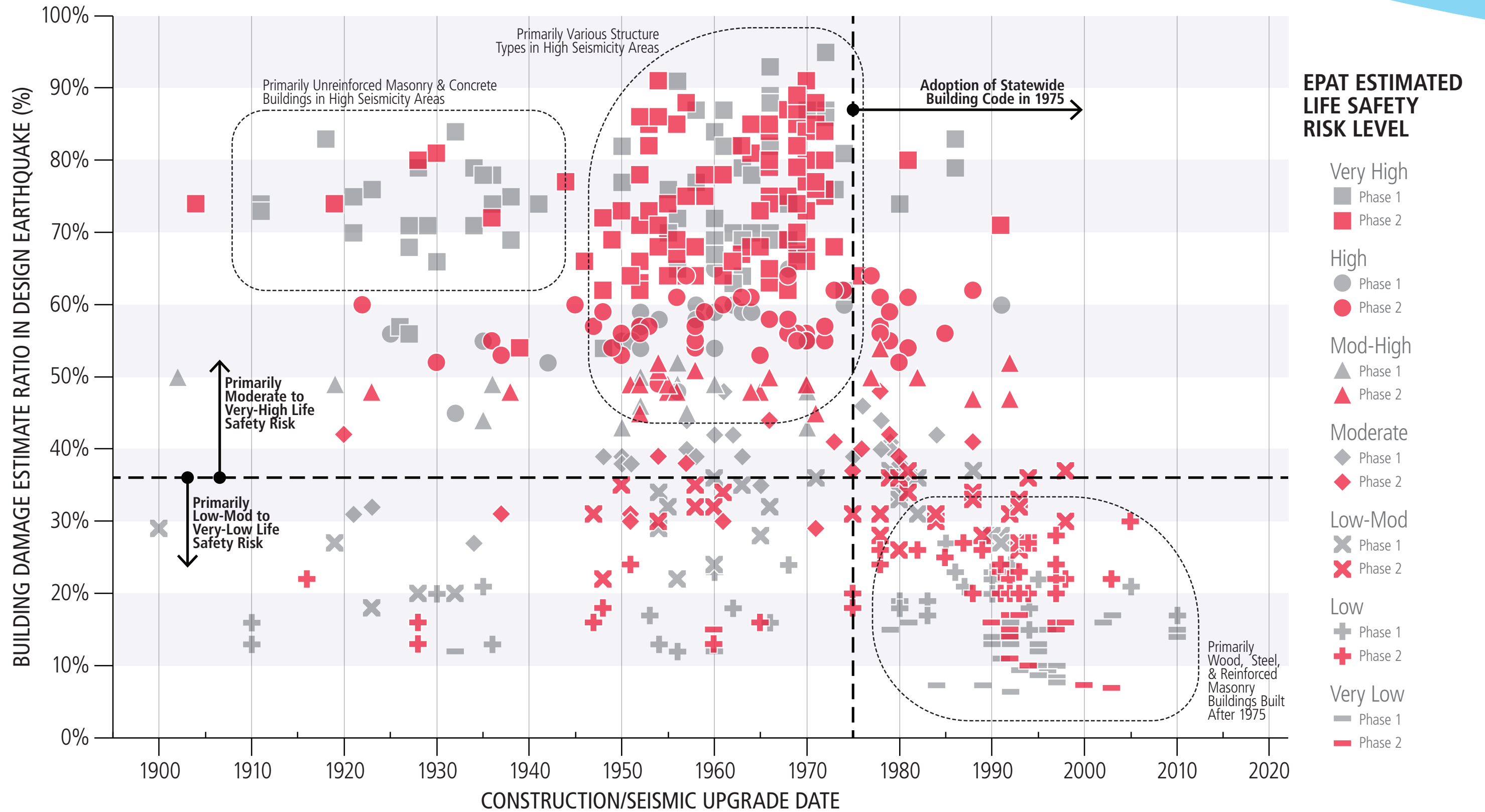


Figure B.1-29 – Phase 1 & Phase 2 – EPAT Estimated Most-Likely Post-Earthquake ATC-20 Tagging After ASCE 7/41 Design-Level Earthquake



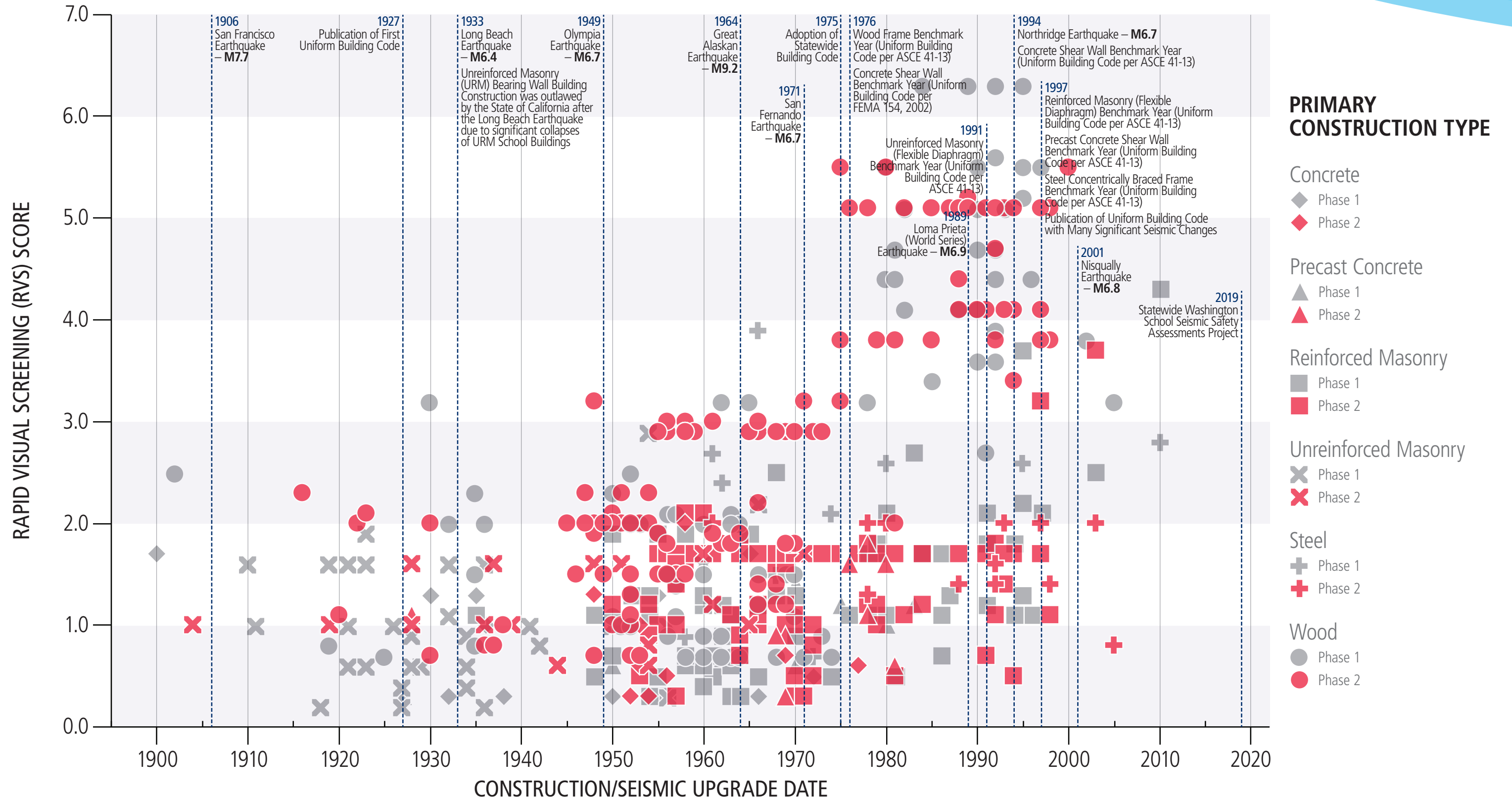


Figure B.1-31 – Phase 1 & Phase 2 – FEMA 154 Rapid Visual Screening (RVS) Score Categorized by Primary Construction Type

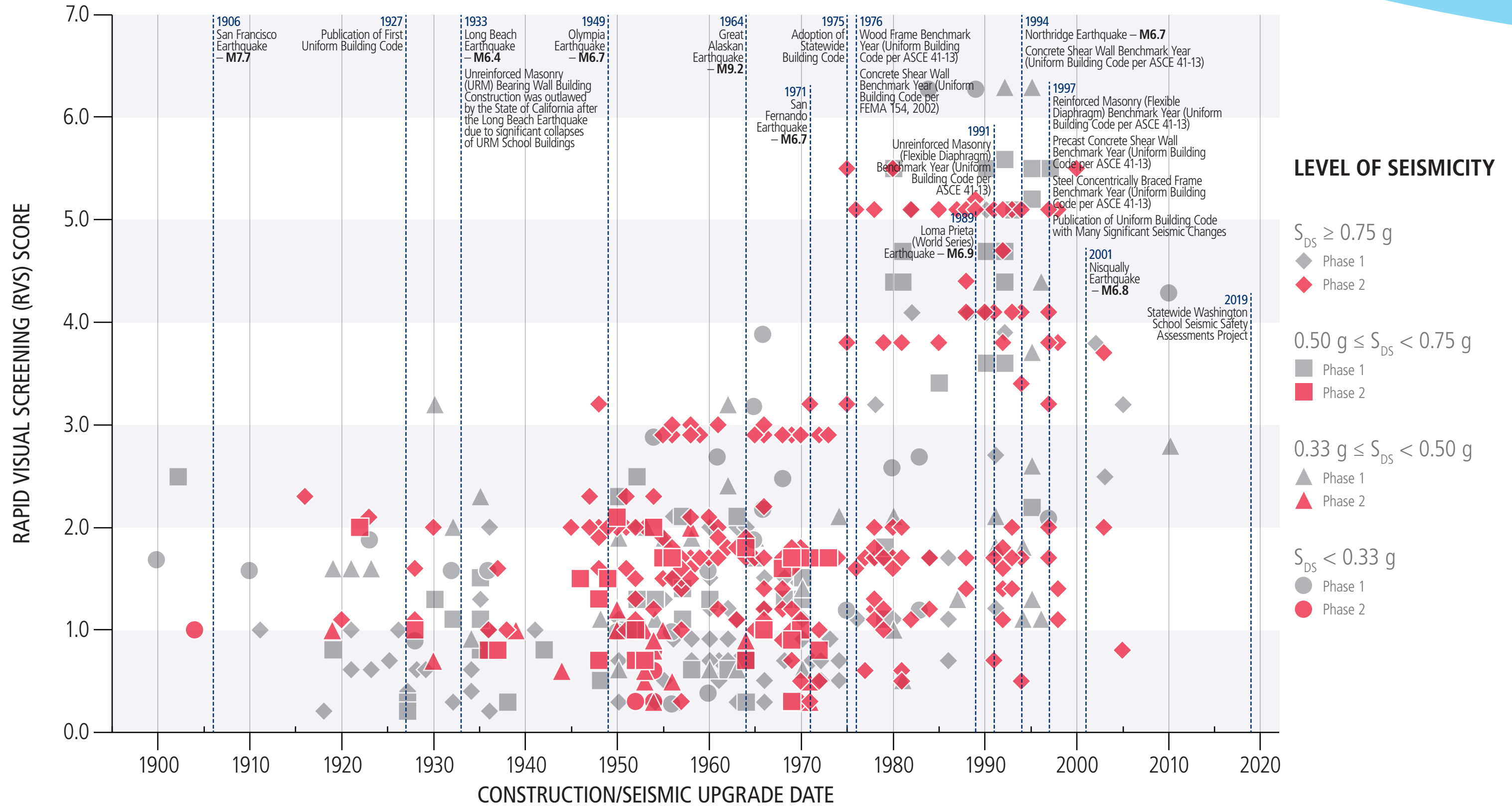
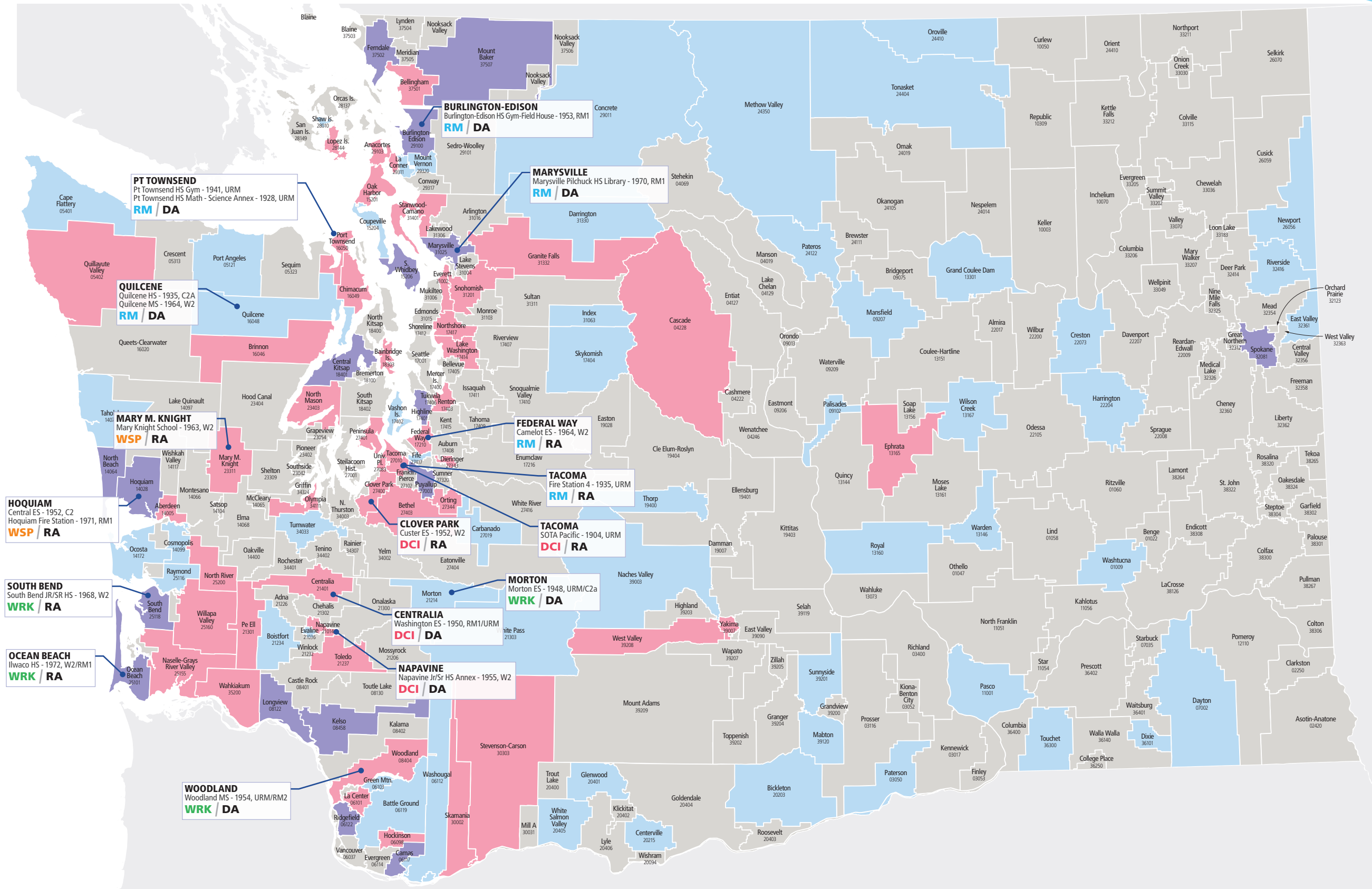


Figure B.1-32 – Phase 1 & Phase 2 – FEMA 154 Rapid Visual Screening (RVS) Score Categorized by Short-Period Spectral Acceleration (S_{DS})

APPENDIX B.2: SCHOOL MAP AND SCHOOL SELECTION LISTS

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LEGEND

- RM** Reid Middleton
- WRK** WRK Engineers
- WSP** WSP USA
- DCI** DCI Engineers
- DA** Dykeman Architects
- RA** Rolluda Architects
- Phase 2 School District
- Phase 1 School District
- Phase 1 & 2 School District
- C2** Concrete Shear Wall w/ Rigid Diaphragms
- C2a** Concrete Shear Wall w/ Flexible Diaphragms
- RM1** Reinforced Masonry Walls w/ Flexible Diaphragms
- RM2** Reinforced Masonry Wall w/ Rigid Diaphragms
- W2** Wood Frame
- URM** Unreinforced Masonry Bearing Walls w/ Flexible Diaphragms

District Name	ICOS Site ID	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renovation	Gross Area (SF)	No. of Floors	Structural Drawings Avail? (Yes, No, Partial)	Has Had Structural Upgrade?	Year of Structural Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Sds, BSE-1N (g)	ASCE 41 Tier 1 Assessed By
Aberdeen	21443	A.J. West Elementary School	57384	1952 Building	46.972	-123.838	W2	1952	1952	22,630	2	P	Yes	1994	YES	E	128.0	1.32	WSP
Aberdeen	21443	A.J. West Elementary School	57385	Annex Building	46.972	-123.838	W2	1966	1994	16,400	1	P	Yes	1994	YES	E	128.0	1.32	WSP
Aberdeen	21445	Central Park Elementary School	57391	Annex Building	46.968	-123.698	RM1	1966	1995	5,895	1	P	No		NO	D	339.0	0.99	WSP
Aberdeen	21445	Central Park Elementary School	57392	Main Building	46.968	-123.698	W2	1956	1995	21,446	1	P	No		NO	D	339.0	0.99	WSP
Aberdeen	21446	Hopkins Building (Harbor High School)	57394	Hopkins Building	46.972	-123.832	C2a	1956		53,604	1	Y	No		YES	E	140.0	1.32	WSP
Aberdeen	21441	J. M. Weatherwax High School	57378	1964 Gymnasium Building	46.980	-123.818	RM1	1964		27,409	3	N	No		YES	E	109.0	1.32	WSP
Aberdeen	21441	J. M. Weatherwax High School	57378	Main Building	46.980	-123.818	S2a	1964		173,011	3	N	No		YES	E	109.0	1.32	WSP
Aberdeen	21448	McDermoth Elementary School	57397	Main Building	46.977	-123.823	W2	1926	1998	61,867	3	P	Yes	1998	YES	D	234.0	1.01	WSP
Anacortes	20899	Mount Erie Elementary School	54084	Main Building	48.487	-122.619	RM1	1955	1991	41,796	1	Y	No		NO	C	522.5	0.92	RM
Bainbridge Island	21451	Bainbridge High School	57407	300 Building	47.637	-122.525	RM1	1981		64,216	2	Y	Yes	1998	NO	D	295.0	0.98	WSP
Bainbridge Island	21451	Bainbridge High School	57410	500 Building	47.637	-122.525	PC1	1981		32,818	2	Y	No		NO	D	295.0	0.98	WSP
Bainbridge Island	21454	Commodore Options School	57422	Art & Classrooms	47.637	-122.522	RM1	1970		17,239	1	Y	No		NO	D	295.0	0.98	WSP
Bainbridge Island	21454	Commodore Options School	57422	Commodore Options School	47.637	-122.522	W2	1948		25,917	1	Y	No		NO	D	295.0	0.98	WSP
Bainbridge Island	21454	Commodore Options School	57422	Eagle Harbor HS	47.637	-122.522	RM1	1981		12,906	1	Y	No		NO	D	295.0	0.97	WSP
Bainbridge Island	21453	Ordway Elementary School	57416	Education Pod	47.640	-122.522	S2a	1978		12,188	1	Y	No		NO	D	295.0	0.97	WSP
Bainbridge Island	21453	Ordway Elementary School	57416	K-4 Building	47.640	-122.522	S2a	1978		15,235	1	Y	No		NO	D	295.0	0.97	WSP
Bainbridge Island	21453	Ordway Elementary School	57416	Main Building	47.640	-122.522	S2a	1978		16,105	1	Y	No		NO	D	295.0	0.97	WSP
Bainbridge Island	21456	Woodward Middle School	57424	2-Story Classroom Wing	47.645	-122.529	W2	1994		56,073	2	Y	No		NO	C	524.0	1.16	WSP
Bainbridge Island	21456	Woodward Middle School	57424	Gym	47.645	-122.529	RM1	1994		15,000	1	Y	No		NO	C	524.0	1.16	WSP
Bainbridge Island	21456	Woodward Middle School	57424	Main Building	47.645	-122.529	RM1	1994		30,201	1	Y	No		NO	C	524.0	1.16	WSP
Bellingham	20974	Fairhaven Middle School	54454	Main Building - Classrooms	48.715	-122.503	W2	1937	1994	62,417	2	Y	Yes	1994	NO	C	525.0	0.81	RM
Bellingham	20974	Fairhaven Middle School	54455	West Wing	48.715	-122.503	W2	1937	1994	11,035	2	Y	Yes	1994	NO	C	525.0	0.81	RM
Bellingham	20985	Roosevelt Elementary School	54493	Main Building	48.768	-122.442	RM1	1972		43,061	1	Y	No		NO	D	274.2	0.73	RM
Bellingham	20980	Whatcom Middle School	54467	Industrial Arts Building	48.759	-122.480	RM1	1978		3,696	1	Y	No		NO	D	262.0	0.73	RM
Bellingham	20980	Whatcom Middle School	54468	Music Building	48.759	-122.480	W2	1971		6,087	1	Y	No		NO	D	262.0	0.73	RM
Bethel	21473	Camas Prairie Elementary School	57577	Main Building	47.097	-122.427	W2	1987		44,728	1	Y	No		NO	C	484.0	1.04	WSP
Bethel	21465	Rocky Ridge Elementary School	57514	Main Building	47.020	-122.346	W2	1985		43,864	1	Y	No		NO	C	502.0	1.00	WSP
Brinnon	21495	Brinnon Elementary School	57777	Main Building	47.697	-122.903	W2	1952		13,737	1	Y	No		NO	C	403.0	1.16	RM
Burlington-Edison	20018	Burlington-Edison High School	50112	500 Wing	48.478	-122.337	RM1	1974		9,171	1	Y	No		NO	D	189.0	0.76	RM
Burlington-Edison	20018	Burlington-Edison High School	50118	Admin/Classroom Building	48.478	-122.337	RM1	1974		13,296	1	Y	No		NO	D	189.0	0.76	RM

District Name	ICOS Site ID	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renovation	Gross Area (SF)	No. of Floors	Structural Drawings Avail? (Yes, No, Partial)	Has Had Structural Upgrade?	Year of Structural Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Sds, BSE-1N (g)	ASCE 41 Tier 1 Assessed By
Burlington-Edison	20018	Burlington-Edison High School	50119	Art/Tiger TUB Building	48.478	-122.337	C2a	1958		15,665	1	Y	No		NO	D	189.0	0.76	RM
Burlington-Edison	20018	Burlington-Edison High School	50117	Cafeteria & 400 Wing	48.478	-122.337	RM1	1970		18,668	1	Y	No		NO	D	189.0	0.76	RM
Burlington-Edison	20018	Burlington-Edison High School	50110	CTE	48.478	-122.337	RM1	1964		5,003	1	Y	No		NO	D	189.0	0.76	RM
Burlington-Edison	20018	Burlington-Edison High School	50109	Fieldhouse 1953 & 1975	48.478	-122.337	RM1	1953	1975	35,093	1	Y	No		NO	D	189.0	0.76	RM
Burlington-Edison	20018	Burlington-Edison High School	50109	Fieldhouse 1984 Addition	48.478	-122.337	RM1	1984		15,040	1	Y	No		NO	D	189.0	0.76	RM
Burlington-Edison	20016	West View Elementary School	50095	Main Building	48.477	-122.341	W2	1950		43,537	1	Y	No		NO	D	189.0	0.76	RM
Camas	21503	Dorothy Fox Elementary School	57808	Main Building	45.599	-122.430	RM1	1982	2011	38,124	1	Y	No		NO	C	397.8	0.66	WRK
Cascade	20302	Beaver Valley School	51675	Main Building	47.770	-120.665	W2	2000		3,141	1	Y	No		NO	C	386.0	0.48	RM
Cascade	20302	Beaver Valley School	51677	Old Winton School House	47.770	-120.665	W2	1916		750	1	N	No		NO	C	386.0	0.48	RM
Central Kitsap	21520	Cottonwood Elementary School	57901	Main	47.643	-122.646	PC1a	1976	2003	54,150	1	Y	Yes	1990	NO	C	364.2	0.99	RM
Central Kitsap	21517	Emerald Heights Elementary	57877	Main	47.675	-122.665	RM1, S2a	1993		56,000	1	Y	No		NO	C	366.1	1.15	RM
Central Kitsap	21516	Green Mountain Elementary	57875	Main	47.599	-122.820	RM1, S2a	1992		43,360	1	Y	No		NO	C	592.2	1.24	RM
Central Kitsap	21512	Pinecrest Elementary	57854	Main Bldg	47.613	-122.636	RM1, S2a	1998		56,181	2	Y	No		NO	C	384.0	1.24	RM
Central Kitsap	21521	Woodlands Elementary	57903	Main	47.630	-122.648	W2	1981		54,243	1	Y	No		NO	D	295.0	1.21	RM
Centralia	21531	Centralia Middle School	57953	Classroom Wings	46.726	-122.982	W2	1958	1987	40,712	1	P	No		NO	C	437.0	0.98	WRK
Centralia	21531	Centralia Middle School	57953	Gym Wing	46.726	-122.982	W2	1958	1987	20,356	1	P	No		NO	C	437.0	0.98	WRK
Centralia	21531	Centralia Middle School	57953	Main Building	46.726	-122.982	W2	1958	1987	27,436	1	P	No		NO	C	437.0	0.98	WRK
Centralia	21534	Oakview Elementary School	57970	Main Building	46.743	-122.952	PC1	1928	1978	38,046	1	P	No		NO	C	415.0	0.99	WRK
Centralia	21533	Washington Elementary School	57962	Main Building	46.709	-122.954	RM1	1950		51,063	1	P	No		NO	D	305.0	0.82	WRK
Chimacum	21545	Chimacum High School	58034	High School 100 Bldg A - North Wing	48.012	-122.778	RM1	1980	1999	38,586	1	Y	Yes	1999	NO	D	332.0	0.88	WSP
Chimacum	21545	Chimacum High School	58034	High School 100 Bldg A - South Wing	48.012	-122.778	RM1	1980	1999	38,600	1	Y	Yes	1999	NO	D	332.0	0.88	WSP
Chimacum	21544	Chimacum Middle School	58032	Middle School Bldg 100 B	48.012	-122.778	RM1	1959	1965	21,558	1	Y	Yes	1999	NO	D	332.0	0.88	WSP
Chimacum	21544	Chimacum Middle School	58031	Middle School Bldg 200	48.012	-122.778	RM1	1991	1999	38,330	1	Y	No		NO	D	332.0	0.88	WSP
Clover Park	20040	Custer Elementary School	50243	Library - CU2	47.181	-122.540	W2	1992	2012	3,264	1	P	No		NO	D	331.0	0.91	DCI
Clover Park	20040	Custer Elementary School	50240	Second Classroom Building - CU1	47.181	-122.540	W2	1952	1992	40,304	1	P	No		NO	D	331.0	0.91	DCI
Clover Park	20041	Oakbrook Elementary School	50244	First Classroom Building - OB1	47.186	-122.549	RM1	1970	2002	37,881	1	P	No		NO	C	454.8	1.09	DCI
Clover Park	20041	Oakbrook Elementary School	50245	Gym / MPR - OB2	47.186	-122.549	RM1	1970		11,760	1	P	No		NO	C	454.8	1.09	DCI
Clover Park	20028	Tillicum Elementary School	50186	Classroom Building - TL1	47.125	-122.553	URM	1944	1997	37,468	1	P	No		NO	C	490.9	1.08	DCI
Dieringer	21550	North Tapps Middle School	58058	Main Building	47.249	-122.161	W2	1992	2008	55,128	1	P	No		NO	C	519.0	0.98	DCI

District Name	ICOS Site ID	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renovation	Gross Area (SF)	No. of Floors	Structural Drawings Avail? (Yes, No, Partial)	Has Had Structural Upgrade?	Year of Structural Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Sds, BSE-1N (g)	ASCE 41 Tier 1 Assessed By
Ephrata	20385	Ephrata High School	51934	1937 Annex (Former Beezley Springs ES)	47.326	-119.551	URM	1937		23,619	1	P	No		NO	D	321.0	0.39	DCI
Ephrata	20385	Ephrata High School	51932	Performing Arts Center PAC	47.326	-119.551	URM	1951		32,125	1	P	No		NO	D	321.0	0.39	DCI
Ephrata	20384	Grant Elementary School	51927	Main Building	47.326	-119.555	RM1	1957	1985	31,612	1	Y	No		NO	D	321.0	0.39	DCI
Ephrata	20386	Parkway School	51938	Main Building	47.313	-119.561	W2	1947	1999	27,288	1	Y	No		NO	C	405.0	0.35	DCI
Everett	21045	Jackson Elementary School	54780	Main Building	47.968	-122.218	W2	1949	1993	51,652	2	Y	Yes	1992	NO	D	344.0	0.85	RM
Everett	21053	Madison Elementary School	54831	Main Building	47.942	-122.224	W2	1947	1993	41,835	1	Y	Yes	1993	NO	C	566.1	1.06	RM
Federal Way	20142	Brigadoon Elementary School	50844	Main Office Building - E	47.300	-122.378	W2	1969	1990	3,706	1	Y	No		NO	C	435.0	1.08	WSP
Federal Way	20142	Brigadoon Elementary School	50838	Multipurpose Building - C	47.300	-122.378	W2	1970		4,823	1	Y	No		NO	C	435.0	1.08	WSP
Federal Way	20142	Brigadoon Elementary School	50843	Rooms 20-25 & Kitchen - B	47.300	-122.378	W2	1969	1990	6,817	1	Y	No		NO	C	435.0	1.08	WSP
Federal Way	20142	Brigadoon Elementary School	50839	Rooms 30-35 - F	47.300	-122.378	W2	1969	1990	6,777	1	Y	No		NO	C	435.0	1.08	WSP
Federal Way	20142	Brigadoon Elementary School	50841	Rooms 40-43 & Library - D	47.300	-122.378	W2	1969	1990	8,596	1	Y	No		NO	C	435.0	1.08	WSP
Federal Way	20142	Brigadoon Elementary School	50842	Rooms 50-58 - A	47.300	-122.378	W2	1969	1990	8,627	1	Y	No		NO	C	435.0	1.08	WSP
Federal Way	20116	Camelot Elementary School	50675	Main Building	47.335	-122.284	W2	1964	1989	41,111	1	Y	No		NO	C	412.0	1.06	WSP
Federal Way	20137	Kilo Middle School	50805	Building A Main Office	47.327	-122.278	W2	1970	1994	6,114	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50803	Building B	47.327	-122.278	W2	1970	1993	12,480	2	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50807	Building C	47.327	-122.278	W2	1970	1993	11,160	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50808	Building D	47.327	-122.278	W2	1970	1993	5,280	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50811	Building E Little Theater	47.327	-122.278	W2	1970		2,316	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50806	Building F1-F4 & Library	47.327	-122.278	W2	1970	1993	9,600	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50804	Building F5-F8	47.327	-122.278	W2	1970	1993	4,320	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50802	Building G	47.327	-122.278	W2	1970	1993	6,720	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50812	Building H Gymnasium	47.327	-122.278	W2	1970		33,152	2	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50809	Building I Cafeteria	47.327	-122.278	W2	1970		7,800	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20137	Kilo Middle School	50810	Building J	47.327	-122.278	W2	1970		8,160	1	Y	No		NO	C	492.0	1.05	WSP
Federal Way	20140	Nautilus K-8 School	50828	Multipurpose Rm Bldg	47.343	-122.322	W2	1968		8,716	1	Y	No		NO	C	386.0	1.08	DCI
Federal Way	20140	Nautilus K-8 School	50825	Rooms 15-20 Bldg	47.343	-122.322	W2	1968		6,852	1	Y	No		NO	C	386.0	1.08	DCI
Federal Way	20140	Nautilus K-8 School	50826	Rooms 1-6 Bldg	47.343	-122.322	W2	1968		6,892	1	Y	No		NO	C	386.0	1.08	DCI
Federal Way	20140	Nautilus K-8 School	50829	Rooms 22-25 Bldg	47.343	-122.322	W2	1968		8,806	1	Y	No		NO	C	386.0	1.08	DCI
Federal Way	20140	Nautilus K-8 School	50830	Rooms 7-14 Bldg	47.343	-122.322	W2	1968		8,658	1	Y	No		NO	C	386.0	1.08	DCI
Federal Way	20121	Sacajawea Middle School	50701	100 Building	47.335	-122.319	RM1	1966		7,682	1	Y	No		NO	C	392.0	1.07	DCI

District Name	ICOS Site ID	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renovation	Gross Area (SF)	No. of Floors	Structural Drawings Avail? (Yes, No, Partial)	Has Had Structural Upgrade?	Year of Structural Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Sds, BSE-1N (g)	ASCE 41 Tier 1 Assessed By
Federal Way	20121	Sacajawea Middle School	50706	300 Building/Cafeteria	47.335	-122.319	RM1	1966		14,503	1	Y	No		NO	C	392.0	1.07	DCI
Federal Way	20121	Sacajawea Middle School	50703	400 Building	47.335	-122.319	RM1	1966		7,473	1	Y	No		NO	C	392.0	1.07	DCI
Federal Way	20121	Sacajawea Middle School	50702	600/700/800 Building	47.335	-122.319	RM1	1966		19,824	1	Y	No		NO	C	392.0	1.07	DCI
Federal Way	20121	Sacajawea Middle School	50700	900 Building	47.335	-122.319	RM1	1968		4,674	1	Y	No		NO	C	392.0	1.07	DCI
Federal Way	20121	Sacajawea Middle School	50705	Gym (500) Building	47.335	-122.319	RM1	1966		17,484	1	Y	No		NO	C	392.0	1.07	DCI
Federal Way	20121	Sacajawea Middle School	50704	Main Office Building	47.335	-122.319	RM1	1968		10,553	1	Y	No		NO	C	392.0	1.07	DCI
Ferndale	21070	Central Elementary School	54971	Main Building	48.845	-122.592	W2	1920		44,516	2	P	Yes	1995	NO	E	151.0	0.87	RM
Ferndale	21073	Custer Elementary	54976	Main Building	48.919	-122.637	W2	1936	2009	49,103	1	P	No		NO	D	191.4	0.73	RM
Granite Falls	21083	Crossroads High School (form. MS)	55015	Crossroads HS	48.085	-121.964	RM1	2000		29,700	2	Y	No		NO	D	268.0	0.87	RM
Granite Falls	21086	Granite Falls Middle School (form. HS)	55028	Main Building - Gym	48.087	-121.963	RM1	1974	2001	30,172	1	Y	No		NO	C	395.0	0.74	RM
Granite Falls	21086	Granite Falls Middle School (form. HS)	55028	Main Building (Excl. Gym)	48.087	-121.963	RM1	1974	2001	32,919	1	Y	No		NO	C	395.0	0.74	RM
Granite Falls	21086	Granite Falls Middle School (form. HS)	55030	Multi-Purpose Building	48.087	-121.963	W2	1980		4,458	1	Y	No		NO	C	395.0	0.74	RM
Granite Falls	21082	Mountain Way Elementary School	55012	Main Building	48.090	-121.970	W2	1988		51,515	1	Y	No		NO	C	441.0	0.81	RM
Highline	21094	Beverly Park @ Glendale Elementary School	55096	Main Building A	47.510	-122.318	RM1	1963	1992	42,692	1	Y	No		NO	C	443.2	1.23	WSP
Highline	21094	Beverly Park @ Glendale Elementary School	55097	Multi-Purpose Building B	47.510	-122.318	RM1	1963	1992	15,453	1	Y	No		NO	C	443.2	1.23	WSP
Highline	21090	Chinook Middle School	55065	100 Building	47.435	-122.282	W2	1956		40,473	1	Y	No		NO	C	469.0	1.16	WSP
Highline	21090	Chinook Middle School	55067	200 Building	47.435	-122.282	W2	1956		14,953	1	Y	No		NO	C	469.0	1.16	WSP
Highline	21090	Chinook Middle School	55063	300 Building - Gymnasium	47.435	-122.282	W2	1956		24,625	1	Y	No		NO	C	469.0	1.16	WSP
Highline	21090	Chinook Middle School	55066	400 Building - Cafeteria	47.435	-122.282	W2	1956		7,425	1	Y	No		NO	C	469.0	1.16	WSP
Highline	21090	Chinook Middle School	55064	800 Building	47.435	-122.282	W2	1966		13,947	1	Y	No		NO	C	469.0	1.16	WSP
Highline	21109	Hilltop Elementary School	55177	100 Building - Bldg A	47.494	-122.302	RM1	1957	1989	11,990	1	Y	No		NO	D	332.9	1.02	WSP
Highline	21109	Hilltop Elementary School	55176	200 Building - Bldg B	47.494	-122.302	W2	1957		10,789	1	Y	No		NO	D	332.9	1.02	WSP
Highline	21109	Hilltop Elementary School	55178	300 Building - Bldg C	47.494	-122.302	W2	1958		11,541	1	Y	No		NO	D	332.9	1.02	WSP
Highline	21109	Hilltop Elementary School	55175	400 Building - Bldg D	47.494	-122.302	W2	1998		19,880	1	Y	No		NO	D	332.9	1.02	WSP
Highline	21095	Seahurst Elementary School	55100	Main Building	47.472	-122.353	W2	1992		63,917	1	Y	No		NO	C	504.0	1.24	WSP
Highline	21110	Southern Heights Elementary School	55185	Building A	47.502	-122.315	W2	1955	1987	11,595	1	Y	Yes	1987	NO	D	358.0	1.03	WSP
Highline	21110	Southern Heights Elementary School	55186	Building B	47.502	-122.315	W2	1956	1987	9,558	1	Y	Yes	1987	NO	D	358.0	1.03	WSP

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Highline	21110	Southern Heights Elementary School	55188	Building C - Admin/Multi Purpose	47.502	-122.315	RM1	1964	1987	10,566	1	Y	No	1987	NO	D	358.0	1.03	WSP
Highline	21103	Sylvester Middle School	55128	100 Building	47.458	-122.341	W2	1953		36,416	1	Y	No		NO	D	293.3	1.02	WSP
Highline	21103	Sylvester Middle School	55131	200 Building	47.458	-122.341	C2a	1953		10,584	1	Y	No		NO	D	293.3	1.02	WSP
Highline	21103	Sylvester Middle School	55134	300 Building - Gymnasium/Cafeteria	47.458	-122.341	C2a	1953	1969	26,029	1	Y	No		NO	D	293.3	1.02	WSP
Highline	21103	Sylvester Middle School	55130	400 Building	47.458	-122.341	C2a	1953		6,327	1	Y	No		NO	D	293.3	1.02	WSP
Highline	21103	Sylvester Middle School	55133	500 Building - Library	47.458	-122.341	C2a	1969		4,560	1	Y	No		NO	D	293.3	1.02	WSP
Highline	21103	Sylvester Middle School	55129	600 Building	47.458	-122.341	C2a	1969		4,141	1	Y	No		NO	D	293.3	1.02	WSP
Highline	21103	Sylvester Middle School	55132	700 Building - Band/Drama	47.458	-122.341	C2a	1969		4,560	1	Y	No		NO	D	293.3	1.02	WSP
Hockinson	21585	Hockinson Heights Elementary School (East)	58331	Building 100 A	45.741	-122.467	RM1	1992		23,845	1	P	No		NO	D	359.0	0.61	WRK
Hockinson	21585	Hockinson Heights Elementary School (East)	58332	Building 200 C	45.741	-122.467	W2	1975	1992	13,934	1	P	No		NO	D	359.0	0.61	WRK
Hockinson	21585	Hockinson Heights Elementary School (East)	58328	Building 300 D	45.741	-122.467	W2	1975	1992	10,154	1	P	No		NO	D	359.0	0.61	WRK
Hockinson	21585	Hockinson Heights Elementary School (East)	58326	Building 400 B	45.741	-122.467	W2	1992		3,982	1	P	No		NO	D	359.0	0.61	WRK
Hockinson	21585	Hockinson Heights Elementary School (East)	58327	Building 500 E	45.741	-122.467	W2	1980	2000	10,091	1	P	No		NO	D	359.0	0.61	WRK
Hockinson	21585	Hockinson Heights Elementary School (East)	58329	Building 600 F	45.741	-122.467	W2	1980	2000	5,254	1	P	No		NO	D	359.0	0.61	WRK
Hockinson	21585	Hockinson Heights Elementary School (East)	58325	Building 800 H	45.741	-122.467	W2	1975	2000	6,904	1	P	No		NO	D	359.0	0.61	WRK
Hoquiam	21588	Central Elementary School	58356	Main Building	46.980	-123.889	C2	1952	2000	38,946	1	P	No		YES	E	168.4	1.33	WSP
Hoquiam	21589	Emerson Elementary School	58357	Main Building	46.981	-123.904	C2	1954	2002	30,641	1	P	No		YES	E	130.8	1.33	WSP
Hoquiam	21586	Hoquiam High School	58347	D-Business Education	46.983	-123.910	W2	1966		9,513	1	P	No		YES	D	242.0	1.02	WSP
Hoquiam	21586	Hoquiam High School	58345	F-Humanities	46.983	-123.910	W2	1966		11,954	1	P	No		YES	D	242.0	1.02	WSP
Hoquiam	21586	Hoquiam High School	58346	G-Little Theater	46.983	-123.910	RM1	1966		14,607	1	P	No		YES	D	242.0	1.02	WSP
Kelso	21596	Coweeman Middle School	58393	Main Building	46.144	-122.889	W2	1961		76,925	1	Y	No		NO	E	111.8	0.77	WRK
Kelso	21597	Rose Valley Elementary School	58396	Main Building	46.098	-122.827	URM	1939	1984	21,937	2	Y	No		NO	C	423.0	0.69	WRK
La Center	20153	La Center Elementary & Middle Schools	50901	Building 300 - ES Main Building	45.861	-122.664	W2	1938	2004	31,357	1	Y	No		NO	D	353.0	0.63	WRK
Lake Washington	21226	Dickinson Elementary School	55935	Main Building	47.669	-122.062	W2	1992		49,156	1	Y	No		NO	C	499.3	1.01	RM
Lake Washington	21212	Einstein Elementary School	55836	Main Building	47.702	-122.098	S2a	1997		50,253	2	Y	No		NO	C	450.0	1.01	RM
Lake Washington	21223	Emerson Campus	55920	Emerson	47.656	-122.194	W2	1982		28,187	1	Y	No		NO	D	341.3	0.85	RM
Lake Washington	21201	Rockwell Elementary School	55771	Main Building	47.699	-122.126	RM1	1986		48,953	1	Y	No		NO	D	353.3	0.84	RM

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Lake Washington	21214	Wilder Elementary School	55846	Main Building	47.719	-122.041	W2	1989		49,154	1	Y	No		NO	C	549.8	1.02	RM
Longview	21614	Mint Valley Elementary School	58459	Building A - 1	46.166	-122.974	RM1	1969		7,683	1	Y	No		YES	E	159.0	0.79	WRK
Longview	21614	Mint Valley Elementary School	58458	Building B - 2	46.166	-122.974	RM1	1969		7,046	1	Y	No		YES	E	159.0	0.79	WRK
Longview	21614	Mint Valley Elementary School	58461	Building D - 4	46.166	-122.974	RM1	1969		6,427	1	Y	No		YES	E	159.0	0.79	WRK
Longview	21615	Mt. Solo Middle School	58466	Main Building	46.165	-123.020	RM1	2003		81,210	1	Y	No		YES	E	142.0	0.80	WRK
Longview	21612	Northlake Elementary School	58447	Main Building	46.145	-122.944	W2	1954		32,363	1	N	No		NO	D-E*	#N/A	0.78	WRK
Longview	21607	Olympic Elementary School	58438	Annex Building	46.139	-122.962	W2	1958		6,583	1	N	No		NO	E	159.0	0.78	WRK
Longview	21607	Olympic Elementary School	58436	Main Building	46.139	-122.962	W2	1950		27,618	1	N	No		NO	E	159.0	0.78	WRK
Longview	21607	Olympic Elementary School	58437	Multipurpose Building	46.139	-122.962	RM1	1958		8,323	1	N	No		NO	E	159.0	0.78	WRK
Longview	21605	Robert Gray Elementary School	58432	Main Building	46.171	-122.993	RM2	1997		49,730	1	Y	No		YES	E	119.0	0.80	WRK
Lopez Island	21248	Lopez Elementary School	56065	Elementary	48.492	-122.897	W2	1978		24,469	1	Y	No		NO	C	413.4	0.98	WRK
Lopez Island	21249	Lopez Middle High School	56067	Gym/Tech Building	48.492	-122.899	RM1	1988		19,750	1	Y	No		NO	C	413.4	0.98	WRK
Lopez Island	21249	Lopez Middle High School	56068	Junior Senior High Building	48.492	-122.899	W2	1930		13,724	1	N	No		NO	C	413.4	0.98	WRK
Mary M Knight	20155	Mary M. Knight School	50921	Elementary School	47.199	-123.432	W2	1963		13,333	1	Y	No		NO	C	427.0	1.25	WSP
Mary M Knight	20155	Mary M. Knight School	50924	High School Building	47.199	-123.432	W2	1979		29,349	1	Y	No		NO	C	427.0	1.25	WSP
Marysville	21255	Cascade Elementary School	56103	Unit A	48.085	-122.160	RM1, W2	1955		12,730	1	Y	Yes	1972	NO	D	288.8	0.77	RM
Marysville	21255	Cascade Elementary School	56101	Unit B	48.085	-122.160	RM1, W2	1955		12,110	1	Y	No		NO	D	288.8	0.77	RM
Marysville	21255	Cascade Elementary School	56104	Unit C	48.085	-122.160	RM1, W2	1956		4,976	1	Y	Yes	1972	NO	D	288.8	0.77	RM
Marysville	21255	Cascade Elementary School	56102	Unit D	48.085	-122.160	RM1, W2	1956		7,868	1	Y	Yes	1972	NO	D	288.8	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56254	Arts & Crafts Building - Bldg B	48.096	-122.155	RM1	1970		10,107	1	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56248	Auditorium - Bldg K	48.096	-122.155	RM1	1970		30,632	1	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56242	Business Ed & Home Learning - Bldg C	48.096	-122.155	RM1	1970		11,224	1	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56240	East Building - Bldg H	48.096	-122.155	RM1	1970		8,606	1	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56246	Gym & New Food Commons - Bldg M	48.096	-122.155	RM1	1970		58,730	2	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56244	Library - Bldg J	48.096	-122.155	RM1	1970		19,772	1	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56253	Life Science Building - Bldg F	48.096	-122.155	RM1	1970		10,225	1	N	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56235	Mech Plant & Former Cafeteria - Bldg E	48.096	-122.155	RM1	1970		14,892	1	Y	No		NO	D	304.0	0.77	RM

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Marysville	21268	Marysville Pilchuck Senior High School	56245	Occupational Center - Bldg A	48.096	-122.155	RM1	1970		15,494	1	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56233	Pool Building - Bldg L	48.096	-122.155	RM1	1970		25,116	1	Y	No		NO	D	304.0	0.77	RM
Marysville	21268	Marysville Pilchuck Senior High School	56247	South Building - Bldg N	48.096	-122.155	RM1	1984		9,169	1	N	No		NO	D	304.0	0.77	RM
Marysville	21259	Pinewood Elementary School	56134	Bldg E	48.073	-122.162	RM1	1968		2,045	1	Y	No		NO	D	243.9	0.78	RM
Marysville	21259	Pinewood Elementary School	56141	Bldg L (Library)	48.073	-122.162	RM1	1968		3,747	1	Y	No		NO	D	243.9	0.78	RM
Marysville	21259	Pinewood Elementary School	56139	Bldg M (Gym)	48.073	-122.162	RM1	1968		8,086	1	Y	No		NO	D	243.9	0.78	RM
Marysville	21259	Pinewood Elementary School	56135	Building A	48.073	-122.162	RM1	1968		2,492	1	Y	No		NO	D	243.9	0.78	RM
Marysville	21259	Pinewood Elementary School	56142	Building D	48.073	-122.162	RM1	1968		3,568	1	Y	No		NO	D	243.9	0.78	RM
Marysville	21265	Quil Ceda Tulalip Elementary School	56204	Main Building	48.064	-122.199	W2	1997		48,195	1	Y	No		NO	D	263.0	0.79	RM
Marysville	21270	Shoultes Elementary School	56264	Bldg B (A Bldg in ICOS)	48.118	-122.162	RM1	1958		12,348	1	Y	No		NO	D	252.9	0.77	RM
Marysville	21270	Shoultes Elementary School	56266	Bldg A Gym (B Bldg in ICOS)	48.118	-122.162	RM1	1964		6,448	1	Y	No		NO	D	252.9	0.77	RM
Marysville	21270	Shoultes Elementary School	56265	Bldg D (C Bldg in ICOS)	48.118	-122.162	RM1	1964		10,575	1	Y	No		NO	D	252.9	0.77	RM
Marysville	21270	Shoultes Elementary School	56267	Bldg C (D Bldg in ICOS)	48.118	-122.162	RM1	1967		9,405	1	Y	No		NO	D	252.9	0.77	RM
Mount Baker	21292	Acme Elementary School	56410	Main Building	48.719	-122.209	W2	1937		17,964	1	N	No		NO	D	207.5	0.70	RM
Napavine	21626	Napavine Elementary School	58512	Main Building	46.578	-122.905	W2	1951		15,770	1	Y	No		NO	C	374.7	0.89	WRK
Napavine	21627	Napavine Junior Senior High School	58513	Annex	46.577	-122.904	W2	1955		11,274	1	Y	No		NO	C	374.7	0.89	WRK
Napavine	21627	Napavine Junior Senior High School	58514	Main	46.577	-122.904	S2a	1980		44,360	1	Y	No		NO	C	374.7	0.89	WRK
Naselle-Grays River Valley	20167	Naselle K-12 School	51032	High School/Admin	46.377	-123.801	W2	1952	1995	34,621	1	P	No		NO	D	301.0	0.85	WRK
Naselle-Grays River Valley	20167	Naselle K-12 School	51032	Elementary	46.377	-123.801	W2	1952	1995	29,156	1	Y	No		NO	D	301.0	0.85	WRK
North Beach	21631	North Beach Junior/ Senior High School	58529	Main Building	47.019	-124.158	RM1	1991		71,428	1	Y	No		YES	D	256.0	1.04	WSP
North Mason	21646	Belfair Elementary School	58613	Gymnasium Building	47.439	-122.834	RM1	1970		7,470	1	Y	No		NO	C	376.0	1.30	DCI
North Mason	21646	Belfair Elementary School	58614	Main Building	47.439	-122.834	RM2	1970		33,648	2	Y	No		NO	C	376.0	1.30	DCI
North River	21649	North River School	58630	Elementary	46.775	-123.484	W2	1945		3,702	1	N	No		NO	D	311.0	0.89	WRK
North River	21649	North River School	58634	Gym Home Ec-Cafeteria	46.775	-123.484	W2	1922		9,885	1	N	No		NO	D	311.0	0.89	WRK
North River	21649	North River School	58631	High School & Admin Building	46.775	-123.484	W2	1922		11,228	1	N	No		NO	D	311.0	0.89	WRK
North River	21649	North River School	58636	Talley Building (Music/Art)	46.775	-123.484	W2	1945		2,880	1	N	No		NO	D	311.0	0.89	WRK
Northshore	21333	Canyon Creek Elementary School	56750	Building A - Classroom/Library	47.805	-122.188	W2	1977		17,477	1	Y	No		NO	C	431.0	1.05	RM

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Northshore	21333	Canyon Creek Elementary School	56753	Building C - Cafeteria/Gym	47.805	-122.188	RM1	1977		18,951	1	Y	No		NO	C	431.0	1.05	RM
Northshore	21335	Crystal Springs Elementary School	56775	Building 1 - Admin	47.801	-122.220	RM1	1957		7,626	1	Y	Yes	2010	NO	D	358.0	0.87	RM
Northshore	21335	Crystal Springs Elementary School	56774	Building 2 - Classrooms/Kitchen	47.801	-122.220	RM1	1957		7,172	1	Y	Yes	2010	NO	D	358.0	0.87	RM
Northshore	21335	Crystal Springs Elementary School	56772	Building 3/4 - Classrooms	47.801	-122.220	RM1	1957		9,875	1	Y	Yes	2010	NO	D	358.0	0.87	RM
Northshore	21335	Crystal Springs Elementary School	56770	Building 5 - Classrooms	47.801	-122.220	RM1	1957		4,809	1	Y	Yes	2010	NO	D	358.0	0.87	RM
Northshore	21331	Shelton View Elementary School	56732	Building A1/10 - Classroom	47.786	-122.240	RM1	1969	1989	8,634	1	Y	No		NO	C	431.8	1.03	RM
Northshore	21331	Shelton View Elementary School	56727	Building C - Gym	47.786	-122.240	RM1	1969	1992	5,899	1	Y	No		NO	C	431.8	1.03	RM
Oak Harbor	20207	Clover Valley School	51299	Main Building	48.329	-122.674	W2	1951	2000	38,208	1	Y	No		NO	D	311.0	1.09	RM
Oak Harbor	20206	Oak Harbor Middle School	51291	Band Building	48.294	-122.659	RM1	1959		2,241	1	Y	No		NO	C	499.0	0.91	RM
Oak Harbor	20206	Oak Harbor Middle School	51288	Building B	48.294	-122.659	W2	1961	1999	20,107	1	Y	Yes	1999	NO	C	499.0	0.91	RM
Oak Harbor	20206	Oak Harbor Middle School	51290	C Wing	48.294	-122.659	W2	1961	1999	27,632	1	Y	Yes	1999	NO	C	499.0	0.91	RM
Oak Harbor	20206	Oak Harbor Middle School	51294	D Wing	48.294	-122.659	W2	1948	1983	1,755	1	Y	No		NO	C	499.0	0.91	RM
Oak Harbor	20206	Oak Harbor Middle School	51293	Gym	48.294	-122.659	RM1	1959		12,310	1	Y	Yes	1999	NO	C	499.0	1.09	RM
Oak Harbor	20206	Oak Harbor Middle School	51289	Main Building A	48.294	-122.659	W2	1955	1999	14,896	1	Y	Yes	1999	NO	C	499.0	0.91	RM
Ocean Beach	21653	Kaino Gym	58644	Kaino Gym	46.310	-124.039	W2	1885		3,200	1	N	No		NO	D	184.0	0.86	WRK
Olympia	21670	Boston Harbor Elementary School	58698	Main Building	47.138	-122.886	W2	1991		27,000	1	Y	No		NO	C	444.4	1.16	DCI
Olympia	21662	Thurgood Marshall Middle School	58671	Gym Building	47.062	-122.951	RM1	1994		16,689	1	Y	No		NO	C	454.7	1.15	DCI
Olympia	21662	Thurgood Marshall Middle School	58672	Main Building	47.062	-122.951	W2	1994		56,347	1	Y	No		NO	C	454.7	1.15	DCI
Orting	21681	Orting Primary School	58761	Main Building	47.101	-122.207	W2	1968		21,945	1	Y	No		NO	D	267.0	0.82	WSP
Pe Ell	20211	Pe Ell School	51320	Fitness Center	46.575	-123.300	W2	1993		1,500	1	P	No		NO	C	388.4	0.94	WRK
Pe Ell	20211	Pe Ell School	51321	Main Building	46.575	-123.300	URM	1954	2006	64,492	1	P	No		NO	C	388.4	0.94	WRK
Peninsula	21697	Discovery Elementary School	58839	Main Building	47.332	-122.604	PC1	1980	1988	40,337	1	Y	No		NO	C	397.0	1.19	DCI
Peninsula	21692	Gig Harbor High School	58821	Main Building	47.331	-122.605	RM1	1978	1991	134,248	2	Y	No		NO	C	397.0	1.19	DCI
Peninsula	21692	Gig Harbor High School	58819	Two-Story Building	47.331	-122.605	W2	1991		47,026	1	P	No		NO	C	397.0	1.19	DCI
Peninsula	21692	Gig Harbor High School	58820	Voc-Ed Building	47.331	-122.605	RM1	1978	1982	12,544	1	P	No		NO	C	397.0	1.19	DCI
Peninsula	21695	Minter Creek Elementary School	58834	Main Building	47.373	-122.693	W2	1981		36,146	1	Y	No		NO	C	401.0	1.27	DCI
Peninsula	21685	Peninsula High School	58793	500 Building	47.386	-122.624	W2	1946	1981	18,439	1	P	No		NO	C	368.0	1.27	DCI
Peninsula	21685	Peninsula High School	58795	600 Building	47.386	-122.624	W2	1962	1981	13,991	2	P	No		NO	C	368.0	1.27	DCI
Peninsula	21685	Peninsula High School	58791	700 Building - Voc Ag	47.386	-122.624	PC1	1978		6,631	1	P	No		NO	C	368.0	1.27	DCI
Peninsula	21685	Peninsula High School	58792	800 Building - Auditorium Area	47.386	-122.624	W2	1970	1992	19,451	1	P	No		NO	C	368.0	1.27	DCI

District Name	ICOS Site ID	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renovation	Gross Area (SF)	No. of Floors	Structural Drawings Avail? (Yes, No, Partial)	Has Had Structural Upgrade?	Year of Structural Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Sds, BSE-1N (g)	ASCE 41 Tier 1 Assessed By
Peninsula	21685	Peninsula High School	58794	900 Building - Pool Building	47.386	-122.624	W2	1969	1992	19,098	2	P	No		NO	C	368.0	1.27	DCI
Peninsula	21685	Peninsula High School	58796	Main Building (100, 200, 300, 400)	47.386	-122.624	W2	1946	1992	92,460	2	P	No		NO	C	368.0	1.27	DCI
Peninsula	21691	Voyager Elementary School	58817	Main Building	47.309	-122.679	W2	1988		41,088	1	Y	No		NO	D	323.3	0.99	DCI
Port Townsend	21715	Blue Heron Middle School	58917	Main Building	48.129	-122.779	CFS2	1995		60,124	1	Y	No		NO	D	350.0	0.90	WSP
Puyallup	21734	Meeker Elementary School	59062	Main Building	47.188	-122.299	W2	1923	1979	39,415	1	Y	No		NO	E	171.0	1.10	DCI
Puyallup	21722	Mt View Elementary School	58954	Main Building	47.226	-122.271	W2	1965	1991	11,093	1	Y	No		NO	C	499.8	1.02	DCI
Puyallup	21722	Mt View Elementary School	58954	Multipurpose Building	47.226	-122.271	RM1	1965	1991	5,414	1	Y	No		NO	C	499.8	1.02	DCI
Puyallup	21728	Waller Road Elementary School	59011	Main Building	47.199	-122.389	URM	1936	1985	31,241	1	Y	Yes	1985	NO	C	554.0	1.05	DCI
Puyallup	21716	Wildwood Elementary	58921	Main Building	47.166	-122.274	W2	1965	1991	43,165	1	Y	No		NO	C	504.2	1.01	DCI
Quillayute Valley	21754	Forks Elementary School	59199	Main Building - 1969 Portion	47.948	-124.379	W2	1970	1989	31,392	1	N	No		NO	C	419.0	1.17	WSP
Quillayute Valley	21755	Forks Intermediate School	59203	Main Building - 1952 Portion	47.949	-124.384	W2	1956	1989	24,029	1	N	No		NO	C	419.0	1.17	WSP
Quillayute Valley	21753	Forks Junior-Senior High School	59193	Main Junior High Building - 1949 Portion	47.948	-124.384	W2	1949		9,048	1	N	No		NO	C	419.0	1.17	WSP
Renton	21350	Hazen Senior High School	56887	700 Building	47.501	-122.153	PC1a	1968		24,316	1	Y	No		NO	C	376.0	1.12	RM
Renton	21350	Hazen Senior High School	56888	Bldg 1 Gym/Pool	47.501	-122.153	PC1a	1969		59,744	2	Y	No		NO	C	376.0	1.12	RM
Renton	21350	Hazen Senior High School	56888	Bldg 1 Main Building	47.501	-122.153	PC1a	1969	2002	129,832	1	Y	No		NO	C	376.0	1.12	RM
Renton	21350	Hazen Senior High School	56888	Bldg 1 Music, Band, Cafeteria	47.501	-122.153	PC1a	1969	2002	35,959	1	Y	No		NO	C	376.0	1.12	RM
Renton	21350	Hazen Senior High School	56885	Gym Addition	47.501	-122.153	C2a	1977		23,342	2	Y	No		NO	C	376.0	1.12	RM
Renton	21365	Lindbergh Senior High School	56944	Gym Addition	47.455	-122.167	RM1	1979		7,519	1	Y	No		NO	C	396.7	1.11	RM
Renton	21365	Lindbergh Senior High School	56944	Gymnasium	47.455	-122.167	RM1	1971	2010	37,210	1	Y	Yes	2010	NO	C	396.7	1.11	RM
Renton	21365	Lindbergh Senior High School	56945	Main Building - North	47.455	-122.167	RM1	1971	2003	184,279	1	Y	No		NO	C	396.7	1.11	RM
Renton	21365	Lindbergh Senior High School	56945	Main Building - South	47.455	-122.167	RM1	1971	2003	184,279	1	Y	No		NO	C	396.7	1.11	RM
Renton	21354	Renton Senior High School	56901	Cafeteria/Gym	47.482	-122.212	C2a	1954	2002	90,714	2	Y	Yes	2002	NO	D	272.0	0.96	RM
Ridgefield	21764	South Ridge Elementary School	59234	Main Building	45.766	-122.675	S5a	1961	1993	40,588	1	N	No		NO	D	316.0	0.64	WRK
Skamania	21784	Skamania Elementary School	59377	Main Building	45.617	-122.049	W2	1947		14,277	1	P	No		NO	D	319.0	0.55	WRK
Snohomish	21397	Cathcart Elementary School	57090	100 Building	47.827	-122.122	RM1	1966		4,608	1	N	No		NO	C	474.0	1.06	RM
Snohomish	21397	Cathcart Elementary School	57091	200 Building	47.827	-122.122	RM1	1966		3,371	1	N	No		NO	C	474.0	1.06	RM
Snohomish	21397	Cathcart Elementary School	57089	300 Building	47.827	-122.122	RM1	1966		2,352	1	N	No		NO	C	474.0	1.06	RM
Snohomish	21397	Cathcart Elementary School	57088	400 Building	47.827	-122.122	RM1	1966		4,612	1	N	No		NO	C	474.0	1.06	RM
Snohomish	21397	Cathcart Elementary School	57092	500 Building	47.827	-122.122	RM1	1980		5,766	1	N	No		NO	C	474.0	1.06	RM
Snohomish	21397	Cathcart Elementary School	57094	600 Building	47.827	-122.122	RM1	1966		3,112	1	N	No		NO	C	474.0	1.06	RM

District Name	ICOS Site ID	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renovation	Gross Area (SF)	No. of Floors	Structural Drawings Avail? (Yes, No, Partial)	Has Had Structural Upgrade?	Year of Structural Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Sds, BSE-1N (g)	ASCE 41 Tier 1 Assessed By
Snohomish	21397	Cathcart Elementary School	57093	700 Building	47.827	-122.122	RM1	1970		9,786	1	N	No		NO	C	474.0	1.06	RM
Snohomish	21396	Central Elementary School	57085	Main Building	47.914	-122.092	C2a, W2	1948		30,031	2	N	No		NO	C	438.0	0.97	RM
Snohomish	21406	Emerson Elementary School	57133	Annex	47.925	-122.084	W2	1958		10,393	1	N	No		NO	C	527.6	0.95	RM
Snohomish	21406	Emerson Elementary School	57132	Main Building	47.925	-122.084	W2	1954		29,645	1	N	No		NO	C	527.6	0.95	RM
South Bend	20228	South Bend Jr/Sr High School	51397	Main Building High School	46.662	-123.792	W2	1968	2010	51,000	1	N	No		YES	E	109.0	1.18	WRK
South Whidbey	21424	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57247	A- Classrooms	48.026	-122.456	RM1	1969		7,253	1	N	No		NO	C	460.0	0.95	RM
South Whidbey	21424	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57245	C - Classrooms/Admin	48.026	-122.456	RM1	1969		7,253	1	N	No		NO	C	460.0	0.95	RM
South Whidbey	21424	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57249	D - WIA Office/Classrooms	48.026	-122.456	RM1	1969		8,827	1	P	Yes	1996	NO	C	460.0	0.95	RM
South Whidbey	21424	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57250	E - Classrooms	48.026	-122.456	RM1	1969		4,880	1	P	Yes	1996	NO	C	460.0	0.95	RM
South Whidbey	21424	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57248	F - Multipurpose	48.026	-122.456	W2	1969		6,722	1	Y	Yes	1996	NO	C	460.0	0.95	RM
Spokane	20792	Bancroft (The Community School)	53586	Main Building	47.672	-117.428	URM	1954		26,081	1	Y	No		NO	C	461.0	0.27	DCI
Spokane	20782	Bryant Center	53558	Main Building	47.665	-117.437	RM1	1960		21,163	1	Y	No		NO	C	389.0	0.27	DCI
Spokane	20757	Havermale (Montessori)	53500	Main Building 1928 & 1940 Areas	47.677	-117.432	URMa	1928		43,822	2	N	No		NO	C	449.0	0.27	DCI
Spokane	20757	Havermale (Montessori)	53500	Main Building 1928 Gym	47.677	-117.432	URM	1928		8,385	1	N	No		NO	C	449.0	0.27	DCI
Spokane	20757	Havermale (Montessori)	53500	Main Building 1965 Areas	47.677	-117.432	URM	1928		31,600	2	Y	No		NO	C	449.0	0.27	DCI
Spokane	20791	Madison Elementary School	53579	Main Building	47.709	-117.416	URM	1948		35,390	1	Y	No		NO	D	328.8	0.32	DCI
Stanwood-Camano	20237	Stanwood Elementary School	51456	Main Building Unit C 1966	48.245	-122.372	W2	1966		9,504	1	Y	Yes	1995	YES	E	176.0	1.01	RM
Stanwood-Camano	20237	Stanwood Elementary School	51456	Main Building Unit C 1981	48.245	-122.372	W2	1981		10,909	1	Y	No		YES	E	176.0	1.01	RM
Stanwood-Camano	20237	Stanwood Elementary School	51456	Main Building Units A, B	48.245	-122.372	W2	1956	1996	24,124	1	Y	Yes	1995	YES	E	176.0	1.01	RM
Stanwood-Camano	20235	Stanwood Middle School	51449	Building 3 - Music (Band & Choir)	48.242	-122.361	RM1	1957	1992	4,765	1	Y	No		YES	E	163.0	1.00	RM
Stanwood-Camano	20235	Stanwood Middle School	51448	Main Building (Building 1) Unit D	48.242	-122.361	S2a	1992		8,840	1	Y	No		YES	E	163.0	1.00	RM
Stanwood-Camano	20235	Stanwood Middle School	51448	Main Building (Building 1) Unit G	48.242	-122.361	W2	1989		15,091	2	Y	No		YES	E	163.0	1.00	RM
Stanwood-Camano	20235	Stanwood Middle School	51448	Main Building (Building 1) Units E & F	48.242	-122.361	RM1	1968		12,271	1	Y	No		YES	E	163.0	1.00	RM
Stanwood-Camano	20232	Twin City Elementary School	51411	Main Building	48.235	-122.329	S2a	1988		43,962	2	Y	No		NO	D	300.0	0.79	RM
Stevenson-Carson	21808	Carson Elementary School	59495	Main Building	45.726	-121.813	W2	1951		49,183	1	Y	No		NO	C	419.1	0.49	WRK
Stevenson-Carson	21807	Stevenson High School	59488	Main Building	45.701	-121.887	W2	1954		75,594	2	Y	No		NO	D	270.0	0.53	WRK
Stevenson-Carson	21807	Stevenson High School	59491	Vocational Building	45.701	-121.887	RM1	1964		17,428	1	Y	No		NO	D	270.0	0.53	WRK

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Stevenson-Carson	21810	Wind River Education Center	59499	Main Building	45.726	-121.811	PC1	1970	1985	53,660	1	Y	No		NO	C	419.1	0.49	WRK
Tacoma	21826	DeLong Elementary School	59598	First Bldg-Bldg B	47.249	-122.501	W2	1958	1986	16,249	1	Y	No		NO	C	443.0	1.10	DCI
Tacoma	21826	DeLong Elementary School	59597	Original Bldg-Bldg A	47.249	-122.501	W2	1953	1986	23,244	1	Y	No		NO	C	443.0	1.10	DCI
Tacoma	21867	Edison Elementary School	59747	Main Building	47.204	-122.474	W2	1997		65,034	2	Y	No		NO	C	409.0	1.08	DCI
Tacoma	21883	Foss High School	59802	Gym-Pool-Cafeteria	47.239	-122.495	RM1	1972	2005	99,502	3	Y	No		NO	C	432.0	1.10	DCI
Tacoma	21883	Foss High School	59802	Main Building - 2003 Addition	47.239	-122.495	S2a	2003			2	Y	No		NO	C	432.0	1.10	DCI
Tacoma	21883	Foss High School	59802	Main Building - North	47.239	-122.495	RM2	1972	2005	56,508	1	Y	No		NO	C	432.0	1.10	DCI
Tacoma	21883	Foss High School	59802	Main Building - South	47.239	-122.495	RM2	1972	2005	100,003	3	Y	No		NO	C	432.0	1.10	DCI
Tacoma	21824	Franklin Elementary School	59589	Main Building	47.248	-122.479	RM1	1997		60,957	2	Y	No		NO	C	508.0	1.09	DCI
Tacoma	21884	Larchmont Elementary School	59804	Original Building	47.178	-122.428	W2	1969		33,480	1	Y	No		NO	C	515.7	1.06	DCI
Tacoma	21879	Lister Elementary School	59790	Main Building	47.216	-122.400	W2	1998		72,548	2	Y	No		NO	C	513.0	1.06	DCI
Tacoma	21827	Manitou Park Elementary School	59601	Main Building	47.197	-122.495	W2	1994		69,257	2	Y	No		NO	C	391.2	1.08	DCI
Tacoma	21845	Mann Elementary School	59664	Main Building	47.210	-122.448	W2	1952		55,848	2	Y	No		NO	C	561.0	1.07	DCI
Tacoma	21834	Northeast Tacoma Elementary School	59627	Gym Bldg-Bldg 2	47.282	-122.375	RM1	1993		13,492	1	Y	No		NO	C	453.9	1.07	DCI
Tacoma	21834	Northeast Tacoma Elementary School	59626	Main Bldg-Bldg 1	47.282	-122.375	W2	1993		42,607	2	Y	No		NO	C	453.9	1.07	DCI
Tacoma	21863	Point Defiance Elementary School	59730	Main Building	47.290	-122.518	W2	1959	1987	29,049	1	Y	No		NO	C	428.0	1.13	DCI
Tacoma	21835	Reed Elementary School	59628	Main Building	47.226	-122.461	W2	1950	1987	36,363	2	Y	No		NO	C	439.0	1.08	DCI
Tacoma	21853	Roosevelt Elementary School	59688	Main Bldg	47.228	-122.399	W2	1972		51,763	1	Y	No		NO	C	562.2	1.06	DCI
Tacoma	21861	Sheridan Elementary School	59723	Main Building	47.209	-122.420	W2	1993		58,876	2	Y	No		NO	C	541.0	1.06	DCI
Tacoma	21837	Stanley Elementary School	59636	First Bldg	47.245	-122.460	W2	1989		42,378	1	Y	No		NO	C	452.0	1.09	DCI
Tacoma	21837	Stanley Elementary School	59635	Gym Bldg	47.245	-122.460	RM1	1971	1989	15,061	1	Y	No		NO	C	452.0	1.09	DCI
Tacoma	21872	Tacoma School of the Arts-Pacific	59768	SOTA Pacific Ave	47.244	-122.437	URM	1904		21,601	2	Y	No		NO	C	399.0	1.08	DCI
Tacoma	21862	Willie Stewart Academy	59727	Main Bldg	47.245	-122.443	URM	1919		5,985	1	Y	No		NO	C	549.0	1.08	DCI
Toledo	21891	Toledo Elementary School	59838	Main Building	46.439	-122.853	RM1	1954	1995	51,401	1	P	No		NO	D	241.0	0.74	WRK
Toledo	21892	Toledo Middle School	59842	Classroom Bldg. (Bldg #2)	46.441	-122.850	W2	1952	1996	7,594	2	P	No		NO	C	603.0	0.82	WRK
Toledo	21892	Toledo Middle School	59844	Main Building (Bldg. #1)	46.441	-122.850	W2	1952	1996	35,056	2	P	No		NO	C	603.0	0.82	WRK
University Place	21910	Curtis Senior High School	59969	500 Building	47.222	-122.550	RM1	1971		18,408	1	Y	No		NO	D	343.0	0.92	DCI
University Place	21913	Sunset Primary School	59982	Main Building	47.216	-122.564	W2	1966	1993	37,958	1	Y	No		NO	C	373.2	1.11	DCI
Wahkiakum	20834	Julius A. Wendt Elementary/ John C. Thomas Middle School	53717	J A Wendt Elementary School	46.201	-123.380	W2	1952	1994	28,694	1	N	No		NO	C	396.0	0.83	WRK

District Name	ICOS Site ID	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renovation	Gross Area (SF)	No. of Floors	Structural Drawings Avail? (Yes, No, Partial)	Has Had Structural Upgrade?	Year of Structural Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Sds, BSE-1N (g)	ASCE 41 Tier 1 Assessed By
West Valley (Yakima)	20268	West Valley Junior High School	51547	WVJH (Gym Building)	46.578	-120.608	PC1a	1978		27,797	1	Y	No		NO	C	428.9	0.42	WRK
West Valley (Yakima)	20268	West Valley Junior High School	51546	WVJH (Main Building)	46.578	-120.608	RM2	1978		89,273	1	Y	No		NO	C	428.9	0.42	WRK
White River	20285	Mountain Meadow Elementary School	51616	Main Building	47.151	-122.059	W2	1990		45,060	1	Y	No		NO	C	398.8	0.93	WSP
Willapa Valley	21956	Willapa Elementary School	60150	Main Building	46.676	-123.665	W2	1963	2012	14,041	1	P	No		NO	D	318.0	0.88	WRK
Woodland	21961	Columbia Elementary School	60181	1991 Addition	45.903	-122.753	RM1	1993		13,711	2	N	No		NO	E	158.0	0.71	WRK
Woodland	21961	Columbia Elementary School	60181	Main Building	45.903	-122.753	RM1	1972	1993	47,585	2	P	No		NO	E	158.0	0.71	WRK
Woodland	21963	Woodland Middle School	60193	Gymnasium Building	45.904	-122.748	URM	1954	1983	27,033	1	Y	No		NO	E	158.0	0.71	WRK
Woodland	21963	Woodland Middle School	60193	Main Building	45.904	-122.748	URMa	1954		54,228	1	P	No		NO	E	158.0	0.71	WRK
Woodland	21963	Woodland Middle School	60193	Performing Arts	45.904	-122.748	RM1	1954		9,011	1	P	No		NO	E	158.0	0.71	WRK
Woodland	21963	Woodland Middle School	60192	Shared High School / Middle School	45.904	-122.748	URM	1954		12,167	1	P	No		NO	E	158.0	0.71	WRK
Woodland	21963	Woodland Middle School	60193	Vocational Building	45.904	-122.748	RM1	1954		8,021	1	P	No		NO	E	158.0	0.71	WRK
Yakima	20879	Adams Elementary School	53952	8 Plex Bldg D	46.595	-120.490	URM	1971		8,710	1	Y	No		NO	C	626.6	0.41	WRK
Yakima	20879	Adams Elementary School	53950	BLDG C-1	46.595	-120.490	RM1	1960		4,025	1	Y	No		NO	C	626.6	0.41	WRK
Yakima	20879	Adams Elementary School	53953	Old Gym C	46.595	-120.490	RM1	1960		5,680	1	Y	No		NO	C	626.6	0.41	WRK
Yakima	20890	Hoover Elementary School	54025	Area D - Annex Building	46.581	-120.512	W2	1975		5,050	1	P	No		NO	C	636.0	0.41	WRK
Yakima	20890	Hoover Elementary School	54021	Classrooms - Area F	46.581	-120.512	W2	1975		2,170	1	P	No		NO	C	636.0	0.41	WRK
Yakima	20890	Hoover Elementary School	54023	Main Building - Area A	46.581	-120.512	W2	1948		20,868	1	P	No		NO	C	636.0	0.41	WRK
Yakima	20890	Hoover Elementary School	54023	Main Building - Area B	46.581	-120.512	W2	1948		22,095	1	P	No		NO	C	636.0	0.41	WRK
Yakima	20881	Nob Hill Elementary School	53961	Main Building	46.590	-120.553	URM	1951	1986	36,889	1	Y	No		NO	C	434.0	0.41	WRK
Yakima	20875	Robertson Elementary School	53918	100 Building - Bldg "B"	46.605	-120.547	RM1	1958	1990	1,990	1	Y	No		NO	C	627.0	0.41	WRK
Yakima	20875	Robertson Elementary School	53917	200 Building - Bldg "C"	46.605	-120.547	RM1	1958	1990	4,200	1	Y	No		NO	C	627.0	0.41	WRK
Yakima	20875	Robertson Elementary School	53919	300 Building - Bldg "D"	46.605	-120.547	RM1	1958	1990	6,848	1	Y	No		NO	C	627.0	0.41	WRK
Yakima	20875	Robertson Elementary School	53930	400 Building - Bldg "E"	46.605	-120.547	RM1	1958	1990	6,848	1	Y	No		NO	C	627.0	0.41	WRK
Yakima	20875	Robertson Elementary School	53920	500 Building - Bldg "G"	46.605	-120.547	RM1	1958	1990	5,668	1	Y	No		NO	C	627.0	0.41	WRK
Yakima	20882	Wilson Middle School	53968	Main Building	46.589	-120.567	URMa	1961	1996	82,203	1	P	No		NO	C	560.2	0.42	WRK
Yakima	20882	Wilson Middle School	53969	Science Building	46.589	-120.567	URMa	1961	1996	5,541	1	P	No		NO	C	560.2	0.42	WRK

School Buildings

School District	ICOS Site ID	Facility Name	ICOS Building ID	Building Name	Construction Type	Enrollment	Year Built	Last Major Renovation	Structural Drawings Available?	Seismically Renovated in Past?	Number of Floors	Gross Area (SF)	Tsunami Risk	Site Class	Measured Vs30	BSE-1N, Sds (g)
Burlington-Edison	20018	Burlington-Edison High School	50109	Gymnasium-Fieldhouse	RM1	1082	1953	1985	Yes	No	1	50,133	No	D	189	0.76
Centralia	21533	Washington Elementary School	57962	Main Building	RM1/URM	327	1950		Partial	No	1	51,063	No	D	305	0.82
Clover Park	20040	Custer Elementary School	50240	Classroom Building	W2	283	1952	1992	Partial	No	1	40,304	No	D	331	0.91
Federal Way	20116	Camelot Elementary School	50675	Main Building	W2	353	1964	1989	Yes	No	1	41,111	No	C	412	1.06
Hoquiam	21588	Central Elementary School	58356	Main Building	C2	239	1952	2000	No	No	1	38,946	Yes	E	168	1.33
Marysville	21268	Marysville Pilchuck Senior High School	56244	Library - Bldg J	RM1	1178	1970		Yes	No	1	19,772	No	D	304	0.77
Mary M Knight	20155	Mary M. Knight School	50921	Elementary School	W2	166	1963		Yes	No	1	12,900	No	C	427	1.25
Morton	21623	Morton Elementary School	58501	Main Building	URM & C2a	176	1948	1987	Partial	No	2	25,200	No	C	455	0.72
Napavine	21627	Napavine Junior Senior High School	58513	Annex	W2	400	1955	1973	Yes	No	1	11,274	No	C	375	0.89
Ocean Beach	21656	Ilwaco High School	58649	Ilwaco High School	W2 & C2	286	1971	2014	Yes	No	1, 2 Stories at Gym	89,250	No	D	184	0.92
Port Townsend	21712	Port Townsend High School	58899	Gym	URM	372	1941	1984	No	Partially	1	34,112	No	D	355	0.89
Port Townsend	21712	Port Townsend High School	58900	Math-Science Annex	URM	372	1928	1996	Partial	Partially	2	13,169	No	D	355	0.89
Quilcene	21752	Quilcene High & Elementary School	59188	Middle School	W2	228	1964	1979	Partial	No	1	9,438	No	C	514	0.88
Quilcene	21752	Quilcene High & Elementary School	59184	High School	C2a	228	1935	1975	No	No	2	7,860	No	C	514	0.88
South Bend	20228	South Bend Jr/ Sr High School	51397	Main Building High School	W2	247	1968	2010	Partial	No	1	51,000	Yes	E	109	1.18
Tacoma	21872	Tacoma School of the Arts-Pacific	59768	School of the Arts - Pacific Ave	URM	608	1904		No	No	2	21,601	No	C	339	1.08
Woodland	21963	Woodland Middle School	60193	Gymnasium Building	URM & RM2	708	1954	1983	Yes	No	1	23,100	No	E	158	0.71

Fire Stations

City	Fire Department	Fire Station Name	Construction Type	Year Built	Structural Drawings Available?	Seismically Renovated in Past?	Number of Floors	Gross Area (SF)	Tsunami Risk	Site Class	Measured Vs30	BSE-1N, Sds (g)
Hoquiam	Hoquiam	Hoquiam Fire Station, 8th Street Station	RM1	1971	Partial	No	2	12,908	Yes	E	128	1.32
Tacoma	Tacoma	Tacoma Station 4	URM	1935	Yes	No	1 w/ Partial Basement	6,115	No	C	Not Measured	1.09

APPENDIX B.3: PHASE 1 AND 2 RISK PRIORITIZATION

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VERY HIGH PRIORITY

ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name		
57394	Aberdeen, Harbor High School, Hopkins Building	58356	Hoquiam, Central Elementary School, Main Building	52634	Palisades, Palisades Elementary School, Main Building	59768	Tacoma, Tacoma School of the Arts-Pacific, SOTA Pacific Ave		
57378	Aberdeen, J. M. Weatherwax High School, 1964 Gymnasium Building		58357	Hoquiam, Emerson Elementary School, Main Building	51321		Pe Ell, Pe Ell School, Main Building	59727	Tacoma, Willie Stewart Academy, Main Building
57397	Aberdeen, McDermoth Elementary School, Main Building		58350	Hoquiam, Hoquiam High School, A-Administration	58796		Peninsula, Peninsula High School, Main Building (100, 200, 300, 400)	53670	Thorp, Thorp Elementary & Junior Senior High School, Brick Building
54084	Anacortes, Mount Erie Elementary School		58341	Hoquiam, Hoquiam High School, B-Science	58962		Puyallup, Puyallup High School, Main Building	57368	Vashon Island, Vashon Island High School, Building D - Gymnasium
57720	Boistfort, Boistfort Elementary, Gymnasium Building		58342	Hoquiam, Hoquiam High School, H-Gymnasium	59065		Puyallup, Spinning Elementary School, Main Building	51619	White Salmon Valley, Hulan L. Whitson Elementary School, Main Building
57717	Boistfort, Boistfort Elementary, Main Building	55232	Index, Index Elementary School, Main Building	59185	Quilcene, Quilcene High & Elementary School, Elementary	60193	Woodland, Woodland Middle School, Gymnasium Building		
50119	Burlington-Edison, Burlington-Edison High School, Art/Tiger TUB Building	58401	Kelso, Carrolls Elementary School, Main Building	59184	Quilcene, Quilcene High & Elementary School, High School Building		60193	Woodland, Woodland Middle School, Main Building	
50117	Burlington-Edison, Burlington-Edison High School, Cafeteria & 400 Wing	58396	Kelso, Rose Valley Elementary School, Main Building		59203		Quillayute Valley, Forks Intermediate School, Main Building	60193	Woodland, Woodland Middle School, Performing Arts
50110	Burlington-Edison, Burlington-Edison High School, CTE	55667	La Conner, La Conner High School, High School Auditorium		59193		Quillayute Valley, Forks Jr-Sr High School, Main Jr High Building	60192	Woodland, Woodland Middle School, Shared High School /Middle School
50109	Burlington-Edison, Burlington-Edison High School, Fieldhouse	55672	La Conner, La Conner Middle School (form. Elem.), Old Auditorium/Cafeteria Building		59223		Raymond, Raymond Junior Senior High School, Main Building	60193	Woodland, Woodland Middle School, Vocational Building
50095	Burlington-Edison, West View Elementary School, Main Building	58425	Longview, R. A. Long High School, Gym		56888	Renton, Hazen Senior High School, Building 1 Main Building			
57823	Cape Flattery, Clallam Bay High & Elementary School, High School Building	58427	Longview, R. A. Long High School, Main Building	56888	Renton, Hazen Senior High School, Building 1 (Music, Band, Cafeteria)				
57829	Cape Flattery, Neah Bay Elementary School, Elementary School	58428	Longview, R. A. Long High School, Shop Building	56945	Renton, Lindbergh Senior High School, Main Building - North				
57832	Cape Flattery, Neah Bay Junior/ Senior High School, Neah Bay High School Gym	56248	Marysville, Marysville Pilchuck Sr High School, Auditorium - Building K	56945	Renton, Lindbergh Senior High School, Main Building - South				
57837	Carbonado, Carbonado Historical School 19, A - Main Building	56244	Marysville, Marysville Pilchuck Sr High School, Library - Building J	57083	Skykomish, Skykomish School, Main Building				
51688	Centerville, Centerville Elementary School, Main Building		56233	Marysville, Marysville Pilchuck Sr High School, Pool Building - Building L	57090	Snohomish, Cathcart Elementary School, 100 Building			
57962	Centralia, Washington Elementary School, Main Building		56224	Marysville, Totem Middle School, Cafeteria Gym Building	57085	Snohomish, Central Elementary School, Main Building - Gym			
50186	Clover Park, Tillicum Elementary School, Classroom Building - TL1		58501	Morton, Morton Elementary School, Main Building	57085	Snohomish, Central Elementary School, Main Building			
58128	Evaline, Evaline Elementary School, Main Building		56410	Mount Baker, Acme Elementary School, Main Building	51399	South Bend, South Bend Jr/Sr High School, Koplitz Field House			
55002	Ferndale, Beach Elementary, Main Building	56426	Mount Baker, Mount Baker Senior High School, Field House	51398	South Bend, South Bend Jr/Sr High School, Vocational Building				
54976	Ferndale, Custer Elementary, Main Building	50960	Mount Vernon, Lincoln Elementary School, Main Building	51448	Stanwood-Camano, Stanwood Middle School, Main Building (Building 1) Units E & F				
58305	Green Mountain, Green Mountain School, Main Building		58523	North Beach, Pacific Beach Elementary School, Gym/Lunchroom	59748	Tacoma, Fern Hill Elementary School, Main Building			
55188	Highline, Southern Heights Elementary School, Building C - Admin/Multi Purpose		58642	Ocean Beach, Ilwaco (Hilltop) Middle School, Auditorium	59802	Tacoma, Foss High School, Gym-Pool-Cafeteria			
			58643	Ocean Beach, Ilwaco (Hilltop) Middle School, Main Building	59802	Tacoma, Foss High School, Main Building - South			
					59698	Tacoma, Oakland High School, Main Building			

NOTES

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2. The school buildings in the table above, assessed in SSSP Phases 1 and 2, are listed as a Very High Priority based on original construction date, construction type, seismicity, and the number of Tier 1 screening non-compliant and unknown statements. These buildings should be highly prioritized for seismic improvements. Further assessments by a structural engineering and architecture team will be required to determine the extent of seismic upgrades.
3. Data used for prioritizing the school buildings assessed in this study was gathered from 2018 – 2021. Some school buildings listed are undergoing renovations or have subsequently been upgraded, modernized, or seismically improved voluntarily. Some school buildings listed may have also been slated for replacement or taken out of structural use by the school districts. Such buildings should move down in priority list once the seismic improvements are implemented and reviewed by a structural engineer.

LEGEND

- ABC** Phase 1 Conceptual Upgrade Design School
- ABC** Phase 2 Conceptual Upgrade Design School

HIGH PRIORITY

ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name
57410	Bainbridge Island, Bainbridge High School, 500 Building	57901	Central Kitsap, Cottonwood Elementary School, Gym	51932	Ephrata, Ephrata High School, Performing Arts Center PAC	55067	Highline, Chinook Middle School, 200 Building
57422	Bainbridge Island, Commodore Options School, Commodore Options School	57953	Centralia, Centralia Middle School, Classroom Wings	51927	Ephrata, Grant Elementary School, Main Building	55063	Highline, Chinook Middle School, 300 Building - Gymnasium
57416	Bainbridge Island, Ordway Elementary School, Education Pod	57953	Centralia, Centralia Middle School, Gym Wing	54780	Everett, Jackson Elementary School, Main Building	55066	Highline, Chinook Middle School, 400 Building - Cafeteria
57416	Bainbridge Island, Ordway Elementary School, K-4 Building	57953	Centralia, Centralia Middle School, Main Building	54831	Everett, Madison Elementary School, Main Building	55064	Highline, Chinook Middle School, 800 Building
57416	Bainbridge Island, Ordway Elementary School, Main Building	57958	Centralia, Edison Elementary School, Main Building	50675	Federal Way, Camelot Elementary School, Main Building	55177	Highline, Hilltop Elementary School, 100 Building - Building A
50021	Battle Ground, Prairie High School, 500 Building	57970	Centralia, Oakview Elementary School, Main Building	50809	Federal Way, Kilo Middle School, Building E Little Theater	55176	Highline, Hilltop Elementary School, 200 Building - Building B
50024	Battle Ground, Prairie High School, 600 Building	58032	Chimacum, Chimacum Middle School, Middle School Building 100 B	50805	Federal Way, Kilo Middle School, Building G	55178	Highline, Hilltop Elementary School, 300 Building - Building C
54493	Bellingham, Roosevelt Elementary School, Main Building	50240	Clover Park, Custer Elementary School, Second Classroom Building	50706	Federal Way, Sacajawea Middle School, 100 Building	55128	Highline, Sylvester Middle School, 100 Building
54467	Bellingham, Whatcom Middle School, Industrial Arts Building	50244	Clover Park, Oakbrook Elementary School, First Classroom Building	50704	Federal Way, Sacajawea Middle School, 300 Building/Cafeteria	55131	Highline, Sylvester Middle School, 200 Building
57777	Brinnon, Brinnon Elementary School, Main Building	50245	Clover Park, Oakbrook Elementary School, Gym / MPR	50702	Federal Way, Sacajawea Middle School, 400 Building	55134	Highline, Sylvester Middle School, 300 Building (Gymnasium/Cafeteria)
50112	Burlington-Edison, Burlington-Edison High School, 500 Wing	50245	Clover Park, Oakbrook Elementary School, Gym / MPR	50699	Federal Way, Sacajawea Middle School, 900 Building	55130	Highline, Sylvester Middle School, 400 Building
50118	Burlington-Edison, Burlington-Edison High School, Admin/Classroom Building	54519	Concrete, Concrete High School, Main Building	50705	Federal Way, Sacajawea Middle School, Gym (500) Building	55133	Highline, Sylvester Middle School, 500 Building - Library
57802	Camas, Lacamas Heights Elementary School, 100 Pod	54518	Concrete, Concrete High School, Tech Building	50700	Federal Way, Sacajawea Middle School, Main Office Building	55129	Highline, Sylvester Middle School, 600 Building
57803	Camas, Lacamas Heights Elementary School, Multipurpose	58041	Cosmopolis, Cosmopolis Elementary School, Auditorium Building	54971	Ferndale, Central Elementary School, Main Building	55132	Highline, Sylvester Middle School, 700 Building - Band/Drama
57790	Camas, Liberty Middle School, Main Building	58038	Cosmopolis, Cosmopolis Elementary School, Main Building	58147	Fife, Fife High School, Building IV 400 Library	55073	Highline, Woodside Site, Annex
57791	Camas, Liberty Middle School, Music Building	58037	Cosmopolis, Cosmopolis Elementary School, Multipurpose Building	58144	Fife, Fife High School, Building V 500 Main	55072	Highline, Woodside Site, Main Building
57827	Cape Flattery, Clallam Bay High & Elementary School, Big Gym	54538	Coupeville, Coupeville Elementary School, Cedar Pod	58145	Fife, Fife High School, Building VIII 800 Shop	58325	Hockinson, Hockinson Heights Elementary School (East), Building 800 H
57824	Cape Flattery, Clallam Bay High & Elementary School, Elementary Building	54547	Darrington, Darrington Senior High School, Darrington High School	55015	Granite Falls, Crossroads High School (form. MS), Main Building	58347	Hoquiam, Hoquiam High School, D-Business Education
57822	Cape Flattery, Clallam Bay High & Elementary School, Elementary Gym	54546	Darrington, Darrington Senior High School, Woodshop	55028	Granite Falls, Granite Falls Middle School (form. HS), Main Building - Gym	58344	Hoquiam, Hoquiam High School, E-Library
57825	Cape Flattery, Clallam Bay High & Elementary School, Shop & Art Building	51839	Dayton, Dayton High School, Ag Shop	55028	Granite Falls, Granite Falls Middle School (form. HS), Main Building (Excl. Gym)	58345	Hoquiam, Hoquiam High School, F-Humanities
57833	Cape Flattery, Neah Bay Jr/ Sr High School, Neah Bay High School Classroom Building	51838	Dayton, Dayton High School, High School Building	58303	Green Mountain, Green Mountain School, Gymnasium	58346	Hoquiam, Hoquiam High School, G-Little Theater
57835	Cape Flattery, Neah Bay Jr/ Sr High School, Neah Bay High School Shop Building	51840	Dayton, Dayton High School, Wood Shop	52039	Harrington, Harrington Elementary & High School, Main Building	58355	Hoquiam, Lincoln Elementary School, East Wing
57835	Cape Flattery, Neah Bay Jr/ Sr High School, Neah Bay High School Shop Building	51843	Dixie, Dixie Elementary School, Main Building	55096	Highline, Beverly Park @ Glendale Elementary School, Main Building A	58354	Hoquiam, Lincoln Elementary School, Multipurpose Building
57838	Carbonado, Carbonado Historical School 19, B - Community Gym	50350	East Valley (Yakima), East Valley Central Middle School, Gymnasium Building	55097	Highline, Beverly Park @ Glendale Elementary School, Multi-Purpose Building B	58353	Hoquiam, Lincoln Elementary School, West Wing
51677	Cascade, Beaver Valley School, Old Winton School House	51934	Ephrata, Ephrata High School, 1937 Annex (Former Beezley Springs ES)	55065	Highline, Chinook Middle School, 100 Building	58393	Kelso, Coweeman Middle School, Main Building
						50901	La Center, La Center Elementary & Middle Schools, Building 300 - ES Main Building
						55771	Lake Washington, Rockwell Elementary School, Main Building

NOTES

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2. The school buildings in the table above, assessed in SSSP Phases 1 and 2, are listed as a High Priority based on original construction date, construction type, seismicity, and the number of Tier 1 screening non-compliant and unknown statements. These buildings should be prioritized for seismic improvements. Further assessments by a structural engineering and architecture team will be required to determine the extent of seismic upgrades.
3. Data used for prioritizing the school buildings assessed in this study was gathered from 2018 – 2021. Some school buildings listed are undergoing renovations or have subsequently been upgraded, modernized, or seismically improved voluntarily. Some school buildings listed may have also been slated for replacement or taken out of structural use by the school districts. Such buildings should move down in priority list once the seismic improvements are implemented and reviewed by a structural engineer.

LEGEND

- ABC** Phase 1 Conceptual Upgrade Design School
- ABC** Phase 2 Conceptual Upgrade Design School

HIGH PRIORITY

ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name
58459	Longview, Mint Valley Elementary School, Building A - 1	56253	Marysville, Marysville Pilchuck Sr High School, Life Science Building - Building F	51032	Naselle-Grays River Valley, Naselle K-12 School, Administration/Misc. Building	58649	Ocean Beach, Ilwaco High School, Ilwaco High School
58458	Longview, Mint Valley Elementary School, Building B - 2						
58461	Longview, Mint Valley Elementary School, Building D - 4	56235	Marysville, Marysville Pilchuck Sr High School, Mech Plant & Former Cafeteria - Building E	51032	Naselle-Grays River Valley, Naselle K-12 School, Elementary	58650	Ocean Beach, Ilwaco High School, Stadium Complex
58447	Longview, Northlake Elementary School, Main Building			58529	North Beach, North Beach Junior/Senior High School, Main Building	58645	Ocean Beach, Long Beach Elementary School, Main Building
58438	Longview, Olympic Elementary School, Annex Building	56245	Marysville, Marysville Pilchuck Sr High School, Occupational Center - Building A	58524	North Beach, Pacific Beach Elementary School, Main Building	58761	Orting, Orting Primary School, Main Building
58436	Longview, Olympic Elementary School, Main Building	56134	Marysville, Pinewood Elementary School, Building E	58525	North Beach, Pacific Beach Elementary School, Quad Building	52635	Palisades, Palisades Elementary School, Grange Hall
58437	Longview, Olympic Elementary School, Multipurpose Building	56141	Marysville, Pinewood Elementary School, Building L (Library)	58613	North Mason, Belfair Elementary School, Gymnasium Building	52831	Pateros, Pateros K-12 School, Main Building
58426	Longview, R. A. Long High School, RA Long Annex	56139	Marysville, Pinewood Elementary School, Building M (Gym)	58614	North Mason, Belfair Elementary School, Main Building	52830	Pateros, Pateros K-12 School, Metal Shop
58424	Longview, R. A. Long High School, Science Wing	56135	Marysville, Pinewood Elementary School, Building A	58630	North River, North River School, Elementary	52832	Pateros, Pateros K-12 School, Music Building
56068	Lopez Island, Lopez Middle High School, Junior Senior High Building	56142	Marysville, Pinewood Elementary School, Building D	58634	North River, North River School, Gym Home Ec-Cafeteria	58839	Peninsula, Discovery Elementary School, Main Building
52288	Mabton, Mabton Jr/Sr High School, Main Building	56264	Marysville, Shoultes Elementary School, Building B (A Building in ICOS)	58631	North River, North River School, High School & Admin Building	58821	Peninsula, Gig Harbor High School, Main Building
52289	Mabton, Mabton Jr/Sr High School, Shop/Ag Building	56266	Marysville, Shoultes Elementary School, Building A Gym (B Building in ICOS)	58636	North River, North River School, Talley Building (Music/Art)	58820	Peninsula, Gig Harbor High School, Voc-Ed Building
50921	Mary M Knight, Mary M. Knight School, Elementary School	56265	Marysville, Shoultes Elementary School, Building D (C Building in ICOS)	56750	Northshore, Canyon Creek Elementary School, Building A - Classroom/Library	58793	Peninsula, Peninsula High School, 500 Building
				56753	Northshore, Canyon Creek Elementary School, Building C - Cafeteria/Gym	58795	Peninsula, Peninsula High School, 600 Building
56103	Marysville, Cascade Elementary School, Unit A	56267	Marysville, Shoultes Elementary School, Building C (D Building in ICOS)			58792	Peninsula, Peninsula High School, 800 Building - Auditorium Area
56101	Marysville, Cascade Elementary School, Unit B			56775	Northshore, Crystal Springs Elementary School, Building 1 - Admin	58794	Peninsula, Peninsula High School, 900 Building - Pool Building
56104	Marysville, Cascade Elementary School, Unit C	56232	Marysville, Totem Middle School, Home Economics Building			58899	Port Townsend, Port Townsend High School, Gym
56102	Marysville, Cascade Elementary School, Unit D	56231	Marysville, Totem Middle School, Main Building	56774	Northshore, Crystal Springs Elementary School, Building 2 - Classrooms/Kitchen	58898	Port Townsend, Port Townsend High School, Main Building
56194	Marysville, Liberty Elementary School, Main Building	56227	Marysville, Totem Middle School, School House Cafe			58900	Port Townsend, Port Townsend High School, Math Science Annex
56213	Marysville, Marysville Middle School, Building C - Shop Classrooms	56226	Marysville, Totem Middle School, Science Building	56772	Northshore, Crystal Springs Elementary School, Building 3/4 - Classrooms		
56214	Marysville, Marysville Middle School, Main Building	52355	Methow Valley, Methow Valley Elementary School, Main Building	56770	Northshore, Crystal Springs Elementary School, Building 5 - Classrooms	58901	Port Townsend, Port Townsend High School, Stuart Building
56254	Marysville, Marysville Pilchuck Sr High School, Arts & Crafts Building - Building B	58506	Morton, Morton Junior Senior High School, Gymnasium	56732	Northshore, Shelton View Elementary School, Building A1/10 - Classroom	59005	Puyallup, Maplewood Elementary School, Main Building
56242	Marysville, Marysville Pilchuck Sr High School, Business Ed & Home Learning - Building C	58505	Morton, Morton Junior Senior High School, Main Building	56727	Northshore, Shelton View Elementary School, Building C - Gym	59062	Puyallup, Meeker Elementary School, Main Building
56240	Marysville, Marysville Pilchuck Sr High School, East Building - Building H	58507	Morton, Morton Junior Senior High School, Shop	51299	Oak Harbor, Clover Valley School, Main Building	58954	Puyallup, Mt View Elementary School, Multipurpose Building
56246	Marysville, Marysville Pilchuck Sr High School, Gym & New Food Commons - Building M	58512	Napavine, Napavine Elementary School, Main Building	51291	Oak Harbor, Oak Harbor Middle School, Band Building	58961	Puyallup, Puyallup High School, Gymnasium & Swimming Pool Building
		58513	Napavine, Napavine Junior Senior High School, Annex	51290	Oak Harbor, Oak Harbor Middle School, C Wing - Cafeteria	58959	Puyallup, Puyallup High School, Library Science Building
		58514	Napavine, Napavine Junior Senior High School, Main	51294	Oak Harbor, Oak Harbor Middle School, D Wing	59065	Puyallup, Spinning Elementary School, East, West, Special Education Wings

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2. The school buildings in the table above, assessed in SSSP Phases 1 and 2, are listed as a High Priority based on original construction date, construction type, seismicity, and the number of Tier 1 screening non-compliant and unknown statements. These buildings should be prioritized for seismic improvements. Further assessments by a structural engineering and architecture team will be required to determine the extent of seismic upgrades.
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LEGEND

- ABCPhase 1 Conceptual Upgrade Design School
- ABCPhase 2 Conceptual Upgrade Design School

HIGH PRIORITY

ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name
59011	Puyallup, Waller Road Elementary School, Main Building	57245	South Whidbey, South Whidbey Grades 5 & 6, C - Classrooms/Admin	59802	Tacoma, Foss High School, Main Building - North	53893	Wilson Creek, Wilson Creek K-12, Main - Gym & Classrooms
59188	Quilcene, Quilcene High & Elementary School, Middle School	57249	South Whidbey, South Whidbey Grades 5 & 6, D - WIA Office/Classrooms	59664	Tacoma, Mann Elementary School, Main Building	60181	Woodland, Columbia Elementary School, Main Building
59199	Quillayute Valley, Forks Elementary School, Main Building	57250	South Whidbey, South Whidbey Grades 5 & 6, E - Classrooms	59730	Tacoma, Point Defiance Elementary School, Main Building	53952	Yakima, Adams Elementary School, 8 Plex Building D
59222	Raymond, Raymond Elementary School, Raymond elementary	57248	South Whidbey, South Whidbey Grades 5 & 6, F - Multipurpose	59628	Tacoma, Reed Elementary School, Main Building	53950	Yakima, Adams Elementary School, Building C-1
56887	Renton, Hazen Senior High School, 700 Building	53538	Spokane, Adams Elementary School, Gym & Cafeteria Building	59635	Tacoma, Stanley Elementary School, Gym Building	53953	Yakima, Adams Elementary School, Old Gym C
56888	Renton, Hazen Senior High School, Building 1 Gym/Pool	53538	Spokane, Adams Elementary School, Main Building	59810	Taholah, Taholah School, Main Building	54023	Yakima, Hoover Elementary School, Main Building - Area A
56885	Renton, Hazen Senior High School, Gym Addition	53586	Spokane, Bancroft (The Community School), Main Building	59838	Toledo, Toledo Elementary School, Main Building	54023	Yakima, Hoover Elementary School, Main Building - Area B
56944	Renton, Lindbergh Senior High School, Gym Addition	53558	Spokane, Bryant Center, Main Building	59842	Toledo, Toledo Middle School, Classroom Building. (Building #2)	53961	Yakima, Nob Hill Elementary School, Main Building
56944	Renton, Lindbergh Senior High School, Gymnasium	53500	Spokane, Havermale (Montessori), Main Building 1928 Gym	59844	Toledo, Toledo Middle School, Main Building (Building. #1)	53968	Yakima, Wilson Middle School, Main Building
56901	Renton, Renton Senior High School, Cafeteria/Gym	53500	Spokane, Havermale (Montessori), Main Building 1928 & 1940 Areas	53697	Touchet, Touchet Elementary & High School, Elementary - Main Building	53969	Yakima, Wilson Middle School, Science Building
59234	Ridgefield, South Ridge Elementary School, Main Building	53500	Spokane, Havermale (Montessori), Main Building 1965 Areas	53695	Touchet, Touchet Elementary & High School, Secondary Facility		
59224	Ridgefield, Union Ridge Elementary School, Main Building	53500	Spokane, Havermale (Montessori), Main Building 1965 Areas	59969	University Place, Curtis Senior High School, 500 Building		
53052	Riverside, Chattaroy Elementary School, 35 Wing Building	53496	Spokane, Libby Center, Main Building	59982	University Place, Sunset Primary School, Main Building		
57007	Shaw Island, Shaw Island School, Admin/RR Building	53579	Spokane, Madison Elementary School, Main Building	57366	Vashon Island, Vashon Island High School, Building K - Annex		
57009	Shaw Island, Shaw Island School, Primary Classroom Building	51456	Stanwood-Camano, Stanwood Elementary School, Main Building Unit C 1981	53717	Wahkiakum, Julius A. Wendt ES/John C. Thomas MS, J A Wendt Elementary School		
59377	Skamania, Skamania Elementary School, Main Building	51449	Stanwood-Camano, Stanwood Middle School, Building 3 - Music	60133	Washougal, Hathaway Elementary School, Main Building		
57091	Snohomish, Cathcart Elementary School, 200 Building	51411	Stanwood-Camano, Twin City Elementary School, Main Building	53815	Washtucna, Washtucna Elementary High School, Ag Shop/ Music Room		
57089	Snohomish, Cathcart Elementary School, 300 Building	59495	Stevenson-Carson, Carson Elementary School, Main Building	53817	Washtucna, Washtucna Elementary High School, Main Building		
57088	Snohomish, Cathcart Elementary School, 400 Building	59488	Stevenson-Carson, Stevenson High School, Main Building	51632	White Salmon Valley, Columbia High School, C Court - Gym		
57092	Snohomish, Cathcart Elementary School, 500 Building	59491	Stevenson-Carson, Stevenson High School, Vocational Building	51631	White Salmon Valley, Columbia High School, Library		
57094	Snohomish, Cathcart Elementary School, 600 Building	59499	Stevenson-Carson, Wind River Education Center, Main Building	51628	White Salmon Valley, Columbia High School, Metal /Wood Shop		
57093	Snohomish, Cathcart Elementary School, 700 Building	53661	Sunnyside, Outlook Elementary School, Outlook Elementary Main Building	51638	White Salmon Valley, Wayne M. Henkle Middle School, Middle School		
57132	Snohomish, Emerson Elementary School, Main Building	59597	Tacoma, DeLong Elementary School, Original Building-Building A	60150	Willapa Valley, Willapa Elementary School, Main Building		
51397	South Bend, South Bend Jr/Sr High School, Main Building High School						
57247	South Whidbey, South Whidbey Grades 5 & 6, A - Classrooms						

NOTES

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2. The school buildings in the table above, assessed in SSSP Phases 1 and 2, are listed as a High Priority based on original construction date, construction type, seismicity, and the number of Tier 1 screening non-compliant and unknown statements. These buildings should be prioritized for seismic improvements. Further assessments by a structural engineering and architecture team will be required to determine the extent of seismic upgrades.
3. Data used for prioritizing the school buildings assessed in this study was gathered from 2018 – 2021. Some school buildings listed are undergoing renovations or have subsequently been upgraded, modernized, or seismically improved voluntarily. Some school buildings listed may have also been slated for replacement or taken out of structural use by the school districts. Such buildings should move down in priority list once the seismic improvements are implemented and reviewed by a structural engineer.

LEGEND

- ABCPhase 1 Conceptual Upgrade Design School
- ABCPPhase 2 Conceptual Upgrade Design School

MODERATE PRIORITY

ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name
57384	Aberdeen, A.J. West Elementary School, 1952 Building	50838	Federal Way, Brigadoon Elementary School, Multipurpose Building - C	58329	Hockinson, Hockinson Heights Elementary School (East), Building 600 F	51456	Stanwood-Camano, Stanwood Elementary School, Main Building Unit C 1966
57385	Aberdeen, A.J. West Elementary School, Annex Building	50808	Federal Way, Kilo Middle School, Building A Main Office	58352	Hoquiam, Lincoln Elementary School, Administrative & Library Building	51456	Stanwood-Camano, Stanwood Elementary School, Main Building Units A, B
57391	Aberdeen, Central Park Elementary School, Annex Building	50803	Federal Way, Kilo Middle School, Building B	55668	La Conner, La Conner High School, High School Main Building	51448	Stanwood-Camano, Stanwood Middle School, Main Building (Building 1) Unit D
57392	Aberdeen, Central Park Elementary School, Main Building	50806	Federal Way, Kilo Middle School, Building C	55836	Lake Washington, Einstein Elementary School, Main Building	51448	Stanwood-Camano, Stanwood Middle School, Main Building (Building 1) Unit G
57422	Bainbridge Island, Commodore Options School, Art & Classrooms	50811	Federal Way, Kilo Middle School, Building F1-F4 & Library	58432	Longview, Robert Gray Elementary School, Main Building	59598	Tacoma, DeLong Elementary School, First Building-Building B
57514	Bethel, Rocky Ridge Elementary School, Main Building	50807	Federal Way, Kilo Middle School, Building F5-F8	56065	Lopez Island, Lopez Elementary School, Elementary	59589	Tacoma, Franklin Elementary School, Main Building
51647	Bickleton, Bickleton Elementary & High School, Building B - Vocational/Transportation	50810	Federal Way, Kilo Middle School, Building H Gymnasium	56067	Lopez Island, Lopez Middle High School, Gym/Tech Building	59804	Tacoma, Larchmont Elementary School, Original Building
57808	Camas, Dorothy Fox Elementary School, Main Building	50802	Federal Way, Kilo Middle School, Building I Cafeteria	56212	Marysville, Marysville Middle School, Building B	59790	Tacoma, Lister Elementary School, Main Building
57782	Camas, Skyridge Middle School, Main Building	50812	Federal Way, Kilo Middle School, Building J	56430	Mount Baker, Mount Baker Senior High School, 800 Building (Former Deming Elem.)	59688	Tacoma, Roosevelt Elementary School, Main Building
57877	Central Kitsap, Emerald Heights Elementary, Main	58141	Fife, Fife High School, Building IX 900 Science	52476	Naches Valley, Naches Valley High School, Gym Building	59808	Taholah, Taholah School, Covered Court
58034	Chimacum, Chimacum High School, High School 100 Building A - North Wing	58143	Fife, Fife High School, Building VI 600 Gyms	52476	Naches Valley, Naches Valley High School, Main Building	53696	Touchet, Touchet Elementary & High School, CTE Building
58034	Chimacum, Chimacum High School, High School 100 Building A - South Wing	51977	Glenwood, Glenwood School, Main Building	52475	Naches Valley, Naches Valley High School, Vocational Building	51547	West Valley (Yakima), West Valley Junior High School, WVJH (Gym Building)
54520	Concrete, Concrete K-6 School, Gym	51986	Grand Coulee Dam, Lake Roosevelt K-12, CTE Building	51290	Oak Harbor, Oak Harbor Middle School, C Wing	51546	West Valley (Yakima), West Valley Junior High School, WVJH (Main Building)
54521	Concrete, Concrete K-6 School, Main Building	51988	Grand Coulee Dam, Lake Roosevelt K-12, Wood Shop	51293	Oak Harbor, Oak Harbor Middle School, Gym	51565	White Pass, White Pass Elementary School, Main Building
58040	Cosmopolis, Cosmopolis Elementary School, Gymnasium Building	55030	Granite Falls, Granite Falls Middle School (form. HS), Multi-Purpose Building	51289	Oak Harbor, Oak Harbor Middle School, Main Building A	60181	Woodland, Columbia Elementary School, 1991 Addition
54540	Coupeville, Coupeville Elementary School, Main	55012	Granite Falls, Mountain Way Elementary School, Main Building	58644	Ocean Beach, Kaino Gym, Kaino Gym	54025	Yakima, Hoover Elementary School, Area D - Annex Building
54539	Coupeville, Coupeville Elementary School, Multipurpose	55185	Highline, Southern Heights Elementary School, Building A	58651	Ocosta, Ocosta Junior Senior High School, Junior Senior High	54021	Yakima, Hoover Elementary School, Classrooms - Area F
54534	Coupeville, Coupeville High School, Annex	55186	Highline, Southern Heights Elementary School, Building B	52577	Oroville, Oroville Elementary School, Main Building	53918	Yakima, Robertson Elementary School, 100 Bldg - Building "B"
51841	Dayton, Dayton High School, Gymnasium	58331	Hockinson, Hockinson Heights Elementary School (East), Building 100 A	52838	Paterson, Paterson Elementary School, Main Building	53917	Yakima, Robertson Elementary School, 200 Bldg - Building "C"
51842	Dayton, Dayton K-8 School, Elementary & Middle School Building	58332	Hockinson, Hockinson Heights Elementary School (East), Building 200 C	51320	Pe Ell, Pe Ell School, Fitness Center	53919	Yakima, Robertson Elementary School, 300 Bldg - Building "D"
50345	East Valley (Yakima), East Valley Elementary School, Main Building	58328	Hockinson, Hockinson Heights Elementary School (East), Building 300 D	58869	Port Angeles, Roosevelt Elementary School, Main Building	53930	Yakima, Robertson Elementary School, 400 Bldg - Building "E"
51938	Ephrata, Parkway School, Main Building	58326	Hockinson, Hockinson Heights Elementary School (East), Building 400 B	58954	Puyallup, Mt View Elementary School, Main Building	53920	Yakima, Robertson Elementary School, 500 Bldg - Building "G"
50844	Federal Way, Brigadoon Elementary School, Main Office Building - E	58327	Hockinson, Hockinson Heights Elementary School (East), Building 500 E	58921	Puyallup, Wildwood Elementary, Main Building		
				57133	Snohomish, Emerson Elementary School, Annex		

NOTES

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2. The school buildings in the tables above, assessed in SSSP Phases 1 and 2, are listed as a Moderate Priority based on original construction date, construction type, seismicity, and the number of Tier 1 screening non-compliant and unknown statements. Seismic improvements are still recommended for Moderate priority buildings but can coincide with other systems upgrades or reconfiguration projects. Seismic improvements are encouraged for Lower priority buildings but may not be required for meeting the Life Safety structural performance objective. Further assessments by a structural engineering and architecture team will be required to determine the extent of seismic upgrades.
3. Data used for prioritizing the school buildings assessed in this study was gathered from 2018 – 2021. Some school buildings listed are undergoing renovations or have subsequently been upgraded, modernized, or seismically improved voluntarily. Some school buildings listed may have also been slated for replacement or taken out of structural use by the school districts. Such buildings should move down in priority list once the seismic improvements are implemented and reviewed by a structural engineer.

LEGEND

ABC Phase 1 Conceptual Upgrade Design School

LOWER PRIORITY

ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name	ICOS #	School Dist., Facility Name, Building Name
57378	Aberdeen, J. M. Weatherwax High School, Main Building	57903	Central Kitsap, Woodlands Elementary, Main	52291	Mansfield, Mansfield Elem & High School, Main Building	53054	Riverside, Chattaroy Elementary School, Main Building
57407	Bainbridge Island, Bainbridge High School, 300 Building	58031	Chimacum, Chimacum Middle School, Middle School Building 200	50924	Mary M Knight, Mary M. Knight School, High School Building	53072	Royal, Red Rock Elementary School, Main Building
57422	Bainbridge Island, Commodore Options School, Eagle Harbor HS	50243	Clover Park, Custer Elementary School, Library	56247	Marysville, Marysville Pilchuck Senior High School, South Building - Building N	53076	Royal, Royal High School, B Main Building
57424	Bainbridge Island, Woodward Middle School, 2-Story Classroom Wing	54537	Coupeville, Coupeville High School, Gymnasium	56204	Marysville, Quil Ceda Tulalip Elementary School, Main Building	53080	Royal, Royal Middle School, Main Building
57424	Bainbridge Island, Woodward Middle School, Gym	54544	Coupeville, Coupeville Middle School, Middle & High School Building	52358	Methow Valley, Liberty Bell Junior Senior High School, Main Building	57008	Shaw Island, Shaw Island School, Intermediate Classroom Building
57424	Bainbridge Island, Woodward Middle School, Main Building	51821	Creston, Creston Junior Senior High School, Creston K-12 School Bldg	58504	Morton, Morton Elementary School, Gymnasium	57240	South Whidbey, South Whidbey Elementary School, Main Building
50043	Battle Ground, Maple Grove K-8, Gym	54550	Darrington, Darrington Elementary School, Main Elementary School	56405	Mount Baker, Mount Baker Jr High School, 200 Building - JHS	53564	Spokane, Audubon Elementary School, Main Building
50044	Battle Ground, Maple Grove K-8, Main Building	58058	Dieringer, North Tapps Middle School, Main Building	56404	Mount Baker, Mount Baker Jr High School, Pro-Rate Portion of Commons - Building 100	59747	Tacoma, Edison Elementary School, Main Building
50013	Battle Ground, Prairie High School, 400 Building	50349	East Valley (Yakima), East Valley Central Middle School, 6th Grade Building	56443	Mount Baker, Mount Baker Sr High School, 300 North	59802	Tacoma, Foss High School, Main Building - 2003 Addition
50050	Battle Ground, River Homelink, Main Building	50351	East Valley (Yakima), East Valley Central Middle School, Computer Lab Building	56436	Mount Baker, Mount Baker Sr High School, 300 South	59601	Tacoma, Manitou Park Elementary School, Main Building
54454	Bellingham, Fairhaven Middle School, Main Building	50804	Federal Way, Kilo Middle School, Building D	56425	Mount Baker, Mount Baker Sr High School, 700 Building	59627	Tacoma, Northeast Tacoma Elementary School, Gym Building-Building 2
54455	Bellingham, Fairhaven Middle School, West Wing	50826	Federal Way, Nautilus K-8 School, Multipurpose Rm Building	56440	Mount Baker, Mount Baker Sr High School, Pro-Rate Portion of Commons - Building 100	59626	Tacoma, Northeast Tacoma Elementary School, Main Bldg-Bldg 1
54468	Bellingham, Whatcom Middle School, Music Building	50827	Federal Way, Nautilus K-8 School, Rooms 15-20 Building	52487	Naches Valley, Naches Valley Middle School, Main Building	59723	Tacoma, Sheridan Elementary School, Main Building
57577	Bethel, Camas Prairie Elementary School, Main Building	50828	Federal Way, Nautilus K-8 School, Rooms 1-6 Building	52500	Newport, Newport High School, Main Building	59636	Tacoma, Stanley Elementary School, First Building
51649	Bickleton, Bickleton Elementary & High School, Main Building	50829	Federal Way, Nautilus K-8 School, Rooms 22-25 Building	51288	Oak Harbor, Oak Harbor Middle School, Building B	53671	Thorp, Thorp Elementary & Jr-Sr High School, Thorp Elem/Jr/Sr High School
50089	Burlington-Edison, Edison Elementary School, Original Building	50830	Federal Way, Nautilus K-8 School, Rooms 7-14 Building	58647	Ocean Beach, Ocean Park Elementary School, Main Building	53674	Tonasket, Tonasket Elementary School, Tonasket Elementary
57834	Cape Flattery, Neah Bay Junior/ Senior High School, Neah Bay Middle School & Gym	58132	Fife, Columbia Junior High School, Main Building	58652	Ocosta, Ocosta Elementary School, Primary Addition	53673	Tonasket, Tonasket Middle-High School, High School/Middle School
57840	Carbonado, Carbonado Historical School 19, Computer Lab & Library	58142	Fife, Fife High School, Building VII 700 Cafeteria	58698	Olympia, Boston Harbor Elementary School, Main Building	59890	Tumwater, Black Lake Elementary School, Building A
51675	Cascade, Beaver Valley School, Main Building	55175	Highline, Hilltop Elementary School, 400 Building - Building D	58671	Olympia, Thurgood Marshall Middle School, Gym Building	59893	Tumwater, Black Lake Elementary School, Building B
57877	Central Kitsap, Emerald Heights Elementary, Gym	55100	Highline, Seahurst Elementary School, Main Building	58672	Olympia, Thurgood Marshall Middle School, Main Building	59892	Tumwater, Black Lake Elementary School, Building C
57875	Central Kitsap, Green Mountain Elementary, Gymnasium	55233	Index, Index Elementary School, Enclosed Covered Play	52770	Pasco, Edwin Markham Elementary School, Main Building	53814	Warden, Warden K-12, Cafeteria
57875	Central Kitsap, Green Mountain Elementary, Main	55935	Lake Washington, Dickinson Elementary School, Main Building	52829	Pateros, Pateros K-12 School, Wood Shop	53812	Warden, Warden K-12, Middle School/High School
57854	Central Kitsap, Pinecrest Elementary, Gymnasium	55920	Lake Washington, Emerson Campus, Emerson	58819	Peninsula, Gig Harbor High School, Two-Story Building	51568	White Pass, White Pass Junior Senior High School, Main Building
57854	Central Kitsap, Pinecrest Elementary, Main	55846	Lake Washington, Wilder Elementary School, Main Building	58834	Peninsula, Minter Creek Elementary School, Main Building	51616	White River, Mountain Meadow Elementary School, Main Building
57855	Central Kitsap, Ridgetop Junior High, Main	58466	Longview, Mt. Solo Middle School, Main Building	58817	Peninsula, Voyager Elementary School, Main Building	53895	Wilson Creek, Wilson Creek K-12, Business Building/Home Ec.
57857	Central Kitsap, Silver Ridge Elementary, Main			58917	Port Townsend, Blue Heron Middle School, Main Building	53894	Wilson Creek, Wilson Creek K-12, Gym/Commons
						53892	Wilson Creek, Wilson Creek K-12, Vo-Ag / Science Building

NOTES

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- The school buildings in the tables above, assessed in SSSP Phases 1 and 2, are listed as a Lower Priority based on original construction date, construction type, seismicity, and the number of Tier 1 screening non-compliant and unknown statements. Seismic improvements are still recommended for Moderate priority buildings but can coincide with other systems upgrades or reconfiguration projects. Seismic improvements are encouraged for Lower priority buildings but may not be required for meeting the Life Safety structural performance objective. Further assessments by a structural engineering and architecture team will be required to determine the extent of seismic upgrades.
- Data used for prioritizing the school buildings assessed in this study was gathered from 2018 – 2021. Some school buildings listed are undergoing renovations or have subsequently been upgraded, modernized, or seismically improved voluntarily. Some school buildings listed may have also been slated for replacement or taken out of structural use by the school districts. Such buildings should move down in priority list once the seismic improvements are implemented and reviewed by a structural engineer.

LEGEND

ABC Phase 1 Conceptual Upgrade Design School

APPENDIX B.4: OSPI ICOS DATA FOR EPAT

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District Name	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renov.	Bldg. Code Year	Bldg. Code	Struct. Dwgs. Avail.? (Yes, No, Partial)	Had Struct. Upgrade?	Year of Struct. Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Severe Vertical Irregularity	Moderate Vertical Irregularity	Horizontal Irregularity	ASCE 41 Tier 1
Aberdeen	A.J. West Elementary School	57384	1952 Building	46.972	-123.838	W2	1952	1952			Partial	Yes	1994	YES	E	128.0	No	No	No	Yes
Aberdeen	A.J. West Elementary School	57385	Annex Building	46.972	-123.838	W2	1966	1994			Partial	Yes	1994	YES	E	128.0	No	No	No	Yes
Aberdeen	Central Park Elementary School	57391	Annex Building	46.968	-123.698	RM1	1966	1995			Partial	No		NO	D	339.0	No	No	No	Yes
Aberdeen	Central Park Elementary School	57392	Main Building	46.968	-123.698	W2	1956	1995			Partial	No		NO	D	339.0	No	No	No	Yes
Aberdeen	Hopkins Building (Harbor High School)	57394	Hopkins Building	46.972	-123.832	C2a	1956	-			Yes	No		YES	E	140.0	No	No	Yes	Yes
Aberdeen	J. M. Weatherwax High School	57378	1964 Gymnasium Building	46.980	-123.818	RM1	1964	-	1961	UBC	No	No		YES	E	109.0	No	No	No	Yes
Aberdeen	J. M. Weatherwax High School	57378	Main Building	46.980	-123.818	S2a	1964	-	2003	IBC	No	No		YES	E	109.0	No	Yes	No	Yes
Aberdeen	McDermoth Elementary School	57397	Main Building	46.977	-123.823	W2	1926	1998			Partial	Yes	1998	YES	D	234.0	Yes	No	Yes	Yes
Anacortes	Mount Erie Elementary School	54084	Main Building	48.487	-122.619	RM1	1955	1991			Yes	No		NO	C	522.5	No	Yes	Yes	Yes
Bainbridge Island	Bainbridge High School	57407	300 Building	47.637	-122.525	RM1	1981	-	1979	UBC	Yes	Yes	1998	NO	D	295.0	No	Yes	Yes	Yes
Bainbridge Island	Bainbridge High School	57410	500 Building	47.637	-122.525	PC1	1981	-	1979	UBC	Yes	No		NO	D	295.0	Yes	No	No	Yes
Bainbridge Island	Commodore Options School	57422	Art & Classrooms	47.637	-122.522	RM1	1970	-	1967	UBC	Yes	No		NO	D	295.0	No	No	No	Yes
Bainbridge Island	Commodore Options School	57422	Commodore Options School	47.637	-122.522	W2	1948	-	1946	UBC	Yes	No		NO	D	295.0	No	No	Yes	Yes
Bainbridge Island	Commodore Options School	57422	Eagle Harbor HS	47.637	-122.522	RM1	1981	-	1979	UBC	Yes	No		NO	D	295.0	No	No	No	Yes
Bainbridge Island	Ordway Elementary School	57416	Education Pod	47.640	-122.522	S2a	1978	-	1976	UBC	Yes	No		NO	D	295.0	No	No	No	Yes
Bainbridge Island	Ordway Elementary School	57416	K-4 Building	47.640	-122.522	S2a	1978	-	1976	UBC	Yes	No		NO	D	295.0	No	No	No	Yes
Bainbridge Island	Ordway Elementary School	57416	Main Building	47.640	-122.522	S2a	1978	-	1976	UBC	Yes	No		NO	D	295.0	No	No	Yes	Yes
Bainbridge Island	Woodward Middle School	57424	2-Story Classroom Wing	47.645	-122.529	W2	1994	-	1991	UBC	Yes	No		NO	C	524.0	No	Yes	Yes	Yes
Bainbridge Island	Woodward Middle School	57424	Gym	47.645	-122.529	RM1	1994	-	1991	UBC	Yes	No		NO	C	524.0	No	Yes	Yes	Yes
Bainbridge Island	Woodward Middle School	57424	Main Building	47.645	-122.529	RM1	1994	-	1991	UBC	Yes	No		NO	C	524.0	No	Yes	Yes	Yes
Bellingham	Fairhaven Middle School	54454	Main Building - Classrooms	48.715	-122.503	W2	1937	1994			Yes	Yes	1994	NO	C	525.0	No	No	No	Yes
Bellingham	Fairhaven Middle School	54455	West Wing	48.715	-122.503	W2	1937	1994			Yes	Yes	1994	NO	C	525.0	No	No	No	Yes
Bellingham	Roosevelt Elementary School	54493	Main Building	48.768	-122.442	RM1	1972	-	1970	UBC	Yes	No		NO	D	274.2	No	Yes	Yes	Yes
Bellingham	Whatcom Middle School	54467	Industrial Arts Building	48.759	-122.480	RM1	1978	-			Yes	No		NO	D	262.0	No	No	No	Yes
Bellingham	Whatcom Middle School	54468	Music Building	48.759	-122.480	W2	1971	-			Yes	No		NO	D	262.0	No	No	No	Yes
Bethel	Camas Prairie Elementary School	57577	Main Building	47.097	-122.427	W2	1987	-	1985	UBC	Yes	No		NO	C	484.0	No	No	No	Yes
Bethel	Rocky Ridge Elementary School	57514	Main Building	47.020	-122.346	W2	1985	-	1983	UBC	Yes	No		NO	C	502.0	No	No	No	Yes
Brinnon	Brinnon Elementary School	57777	Main Building	47.697	-122.903	W2	1952	-			Yes	No		NO	C	403.0	No	Yes	Yes	Yes
Burlington-Edison	Burlington-Edison High School	50112	500 Wing	48.478	-122.337	RM1	1974	-			Yes	No		NO	D	189.0	No	No	No	Yes
Burlington-Edison	Burlington-Edison High School	50118	Admin/Classroom Building	48.478	-122.337	RM1	1974	-			Yes	No		NO	D	189.0	No	No	No	Yes
Burlington-Edison	Burlington-Edison High School	50119	Art/Tiger TUB Building	48.478	-122.337	C2a	1958	-	1955	UBC	Yes	No		NO	D	189.0	No	No	No	Yes

District Name	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renov.	Bldg. Code Year	Bldg. Code	Struct. Dwgs. Avail.? (Yes, No, Partial)	Had Struct. Upgrade?	Year of Struct. Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Severe Vertical Irregularity	Moderate Vertical Irregularity	Horizontal Irregularity	ASCE 41 Tier 1
Burlington-Edison	Burlington-Edison High School	50117	Cafeteria & 400 Wing	48.478	-122.337	RM1	1970	-			Yes	No		NO	D	189.0	No	No	Yes	Yes
Burlington-Edison	Burlington-Edison High School	50110	CTE	48.478	-122.337	RM1	1964	-	1967	UBC	Yes	No		NO	D	189.0	No	No	No	Yes
Burlington-Edison	Burlington-Edison High School	50109	Fieldhouse 1953 & 1975	48.478	-122.337	RM1	1953	1975	1952	UBC	Yes	No		NO	D	189.0	No	No	Yes	Yes
Burlington-Edison	Burlington-Edison High School	50109	Fieldhouse 1984 Addition	48.478	-122.337	RM1	1984	-	1982	UBC	Yes	No		NO	D	189.0	No	No	No	Yes
Burlington-Edison	West View Elementary School	50095	Main Building	48.477	-122.341	W2	1950	-			Yes	No		NO	D	189.0	No	No	Yes	Yes
Camas	Dorothy Fox Elementary School	57808	Main Building	45.599	-122.430	RM1	1982	2011			Yes	No		NO	C	397.8	No	No	Yes	Yes
Cascade	Beaver Valley School	51675	Main Building	47.770	-120.665	W2	2000	-	1997	UBC	Yes	No		NO	C	386.0	No	No	No	Yes
Cascade	Beaver Valley School	51677	Old Winton School House	47.770	-120.665	W2	1916	-			No	No		NO	C	386.0	No	No	No	Yes
Central Kitsap	Cottonwood Elementary School	57901	Main	47.643	-122.646	PC1a	1976	2003			Yes	Yes	1990	NO	C	364.2	No	No	No	Yes
Central Kitsap	Emerald Heights Elementary	57877	Main	47.675	-122.665	RM1, S2a	1993	-	1991	UBC	Yes	No		NO	C	366.1	No	No	No	Yes
Central Kitsap	Green Mountain Elementary	57875	Main	47.599	-122.820	RM1, S2a	1992	-	1985	UBC	Yes	No		NO	C	592.2	No	No	No	Yes
Central Kitsap	Pinecrest Elementary	57854	Main Bldg	47.613	-122.636	RM1, S2a	1998	-	1994	UBC	Yes	No		NO	C	384.0	No	No	No	Yes
Central Kitsap	Woodlands Elementary	57903	Main	47.630	-122.648	W2	1981	-	1976	UBC	Yes	No		NO	D	295.0	No	No	No	Yes
Centralia	Centralia Middle School	57953	Classroom Wings	46.726	-122.982	W2	1958	1987			Partial	No		NO	C	437.0	No	No	No	Yes
Centralia	Centralia Middle School	57953	Gym Wing	46.726	-122.982	W2	1958	1987			Partial	No		NO	C	437.0	No	No	No	Yes
Centralia	Centralia Middle School	57953	Main Building	46.726	-122.982	W2	1958	1987			Partial	No		NO	C	437.0	No	No	No	Yes
Centralia	Oakview Elementary School	57970	Main Building	46.743	-122.952	PC1	1928	1978			Partial	No		NO	C	415.0	No	No	No	Yes
Centralia	Washington Elementary School	57962	Main Building	46.709	-122.954	RM1	1950	-			Partial	No		NO	D	305.0	No	No	No	Yes
Chimacum	Chimacum High School	58034	High School 100 Bldg A - North Wing	48.012	-122.778	RM1	1980	1999	1976	UBC	Yes	Yes	1999	NO	D	332.0	No	Yes	No	Yes
Chimacum	Chimacum High School	58034	High School 100 Bldg A - South Wing	48.012	-122.778	RM1	1980	1999	1976	UBC	Yes	Yes	1999	NO	D	332.0	No	Yes	No	Yes
Chimacum	Chimacum Middle School	58032	Middle School Bldg 100 B	48.012	-122.778	RM1	1959	1965			Yes	Yes	1999	NO	D	332.0	No	No	No	Yes
Chimacum	Chimacum Middle School	58031	Middle School Bldg 200	48.012	-122.778	RM1	1991	1999			Yes	No		NO	D	332.0	No	No	No	Yes
Clover Park	Custer Elementary School	50243	Library - CU2	47.181	-122.540	W2	1992	2012	1988	UBC	Partial	No		NO	D	331.0	No	No	No	Yes
Clover Park	Custer Elementary School	50240	Second Classroom Building - CU1	47.181	-122.540	W2	1952	1992	1949	UBC	Partial	No		NO	D	331.0	No	No	No	Yes
Clover Park	Oakbrook Elementary School	50244	First Classroom Building - OB1	47.186	-122.549	RM1	1970	2002	1967	UBC	Partial	No		NO	C	454.8	No	No	No	Yes
Clover Park	Oakbrook Elementary School	50245	Gym / MPR - OB2	47.186	-122.549	RM1	1970	-	1967	UBC	Partial	No		NO	C	454.8	No	No	No	Yes
Clover Park	Tillicum Elementary School	50186	Classroom Building - TL1	47.125	-122.553	URM	1944	1997			Partial	No		NO	C	490.9	No	Yes	No	Yes
Dieringer	North Tapps Middle School	58058	Main Building	47.249	-122.161	W2	1992	2008	1988	UBC	Partial	No		NO	C	519.0	No	No	No	Yes
Ephrata	Ephrata High School	51934	1937 Annex (Former Beezley Springs ES)	47.326	-119.551	URM	1937	-			Partial	No		NO	D	321.0	No	No	No	Yes

District Name	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renov.	Bldg. Code Year	Bldg. Code	Struct. Dwgs. Avail.? (Yes, No, Partial)	Had Struct. Upgrade?	Year of Struct. Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Severe Vertical Irregularity	Moderate Vertical Irregularity	Horizontal Irregularity	ASCE 41 Tier 1
Ephrata	Ephrata High School	51932	Performing Arts Center PAC	47.326	-119.551	URM	1951	-	1949	UBC	Partial	No		NO	D	321.0	No	No	No	Yes
Ephrata	Grant Elementary School	51927	Main Building	47.326	-119.555	RM1	1957	1985			Yes	No		NO	D	321.0	No	Yes	No	Yes
Ephrata	Parkway School	51938	Main Building	47.313	-119.561	W2	1947	1999			Yes	No		NO	C	405.0	No	Yes	No	Yes
Everett	Jackson Elementary School	54780	Main Building	47.968	-122.218	W2	1949	1993			Yes	Yes	1992	NO	D	344.0	No	No	No	Yes
Everett	Madison Elementary School	54831	Main Building	47.942	-122.224	W2	1947	1993			Yes	Yes	1993	NO	C	566.1	No	No	No	Yes
Federal Way	Brigadoon Elementary School	50844	Main Office Building - E	47.300	-122.378	W2	1969	1990	1967	UBC	Yes	No		NO	C	435.0	No	No	No	Yes
Federal Way	Brigadoon Elementary School	50838	Multipurpose Building - C	47.300	-122.378	W2	1970	-	1967	UBC	Yes	No		NO	C	435.0	No	No	No	Yes
Federal Way	Brigadoon Elementary School	50843	Rooms 20-25 & Kitchen - B	47.300	-122.378	W2	1969	1990	1967	UBC	Yes	No		NO	C	435.0	No	No	No	Yes
Federal Way	Brigadoon Elementary School	50839	Rooms 30-35 - F	47.300	-122.378	W2	1969	1990	1967	UBC	Yes	No		NO	C	435.0	No	No	No	Yes
Federal Way	Brigadoon Elementary School	50841	Rooms 40-43 & Library - D	47.300	-122.378	W2	1969	1990	1967	UBC	Yes	No		NO	C	435.0	No	No	No	Yes
Federal Way	Brigadoon Elementary School	50842	Rooms 50-58 - A	47.300	-122.378	W2	1969	1990	1967	UBC	Yes	No		NO	C	435.0	No	No	No	Yes
Federal Way	Camelot Elementary School	50675	Main Building	47.335	-122.284	W2	1964	1989	1961	UBC	Yes	No		NO	C	412.0	No	No	Yes	Yes
Federal Way	Kilo Middle School	50805	Building A Main Office	47.327	-122.278	W2	1970	1994	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50803	Building B	47.327	-122.278	W2	1970	1993	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50807	Building C	47.327	-122.278	W2	1970	1993	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50808	Building D	47.327	-122.278	W2	1970	1993	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50811	Building E Little Theater	47.327	-122.278	W2	1970	-	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50806	Building F1-F4 & Library	47.327	-122.278	W2	1970	1993	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50804	Building F5-F8	47.327	-122.278	W2	1970	1993	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50802	Building G	47.327	-122.278	W2	1970	1993	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50812	Building H Gymnasium	47.327	-122.278	W2	1970	-	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50809	Building I Cafeteria	47.327	-122.278	W2	1970	-	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Kilo Middle School	50810	Building J	47.327	-122.278	W2	1970	-	1967	UBC	Yes	No		NO	C	492.0	No	No	No	Yes
Federal Way	Nautilus K-8 School	50828	Multipurpose Rm Bldg	47.343	-122.322	W2	1968	-	1967	UBC	Yes	No		NO	C	386.0	No	No	No	Yes
Federal Way	Nautilus K-8 School	50825	Rooms 15-20 Bldg	47.343	-122.322	W2	1968	-	1967	UBC	Yes	No		NO	C	386.0	No	No	No	Yes
Federal Way	Nautilus K-8 School	50826	Rooms 1-6 Bldg	47.343	-122.322	W2	1968	-	1967	UBC	Yes	No		NO	C	386.0	No	No	No	Yes
Federal Way	Nautilus K-8 School	50829	Rooms 22-25 Bldg	47.343	-122.322	W2	1968	-	1967	UBC	Yes	No		NO	C	386.0	No	No	No	Yes
Federal Way	Nautilus K-8 School	50830	Rooms 7-14 Bldg	47.343	-122.322	W2	1968	-	1967	UBC	Yes	No		NO	C	386.0	No	No	No	Yes
Federal Way	Sacajawea Middle School	50701	100 Building	47.335	-122.319	RM1	1966	-	1964	UBC	Yes	No		NO	C	392.0	No	No	No	Yes
Federal Way	Sacajawea Middle School	50706	300 Building/Cafeteria	47.335	-122.319	RM1	1966	-	1964	UBC	Yes	No		NO	C	392.0	No	No	No	Yes
Federal Way	Sacajawea Middle School	50703	400 Building	47.335	-122.319	RM1	1966	-	1964	UBC	Yes	No		NO	C	392.0	No	Yes	No	Yes

District Name	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renov.	Bldg. Code Year	Bldg. Code	Struct. Dwgs. Avail.? (Yes, No, Partial)	Had Struct. Upgrade?	Year of Struct. Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Severe Vertical Irregularity	Moderate Vertical Irregularity	Horizontal Irregularity	ASCE 41 Tier 1
Federal Way	Sacajawea Middle School	50702	600/700/800 Building	47.335	-122.319	RM1	1966	-	1964	UBC	Yes	No		NO	C	392.0	No	Yes	No	Yes
Federal Way	Sacajawea Middle School	50700	900 Building	47.335	-122.319	RM1	1968	-	1964	UBC	Yes	No		NO	C	392.0	No	No	No	Yes
Federal Way	Sacajawea Middle School	50705	Gym (500) Building	47.335	-122.319	RM1	1966	-	1964	UBC	Yes	No		NO	C	392.0	No	No	No	Yes
Federal Way	Sacajawea Middle School	50704	Main Office Building	47.335	-122.319	RM1	1968	-	1964	UBC	Yes	No		NO	C	392.0	No	No	No	Yes
Ferndale	Central Elementary School	54971	Main Building	48.845	-122.592	W2	1920	-			Partial	Yes	1995	NO	E	151.0	No	No	Yes	Yes
Ferndale	Custer Elementary	54976	Main Building	48.919	-122.637	W2	1936	2009			Partial	No		NO	D	191.4	No	Yes	Yes	Yes
Granite Falls	Crossroads High School (form. MS)	55015	Crossroads HS	48.085	-121.964	RM1	2000	-	1997	UBC	Yes	No		NO	D	268.0	No	No	No	Yes
Granite Falls	Granite Falls Middle School (form. HS)	55028	Main Building - Gym	48.087	-121.963	RM1	1974	2001			Yes	No		NO	C	395.0	No	No	No	Yes
Granite Falls	Granite Falls Middle School (form. HS)	55028	Main Building (Excl. Gym)	48.087	-121.963	RM1	1974	2001	1970	UBC	Yes	No		NO	C	395.0	No	No	No	Yes
Granite Falls	Granite Falls Middle School (form. HS)	55030	Multi-Purpose Building	48.087	-121.963	W2	1980	-	1976	UBC	Yes	No		NO	C	395.0	No	Yes	No	Yes
Granite Falls	Mountain Way Elementary School	55012	Main Building	48.090	-121.970	W2	1988	-	1985	UBC	Yes	No		NO	C	441.0	No	No	Yes	Yes
Highline	Beverly Park @ Glendale Elementary School	55096	Main Building A	47.510	-122.318	RM1	1963	1992			Yes	No		NO	C	443.2	No	No	No	Yes
Highline	Beverly Park @ Glendale Elementary School	55097	Multi-Purpose Building B	47.510	-122.318	RM1	1963	1992			Yes	No		NO	C	443.2	No	No	No	Yes
Highline	Chinook Middle School	55065	100 Building	47.435	-122.282	W2	1956	-			Yes	No		NO	C	469.0	No	No	No	Yes
Highline	Chinook Middle School	55067	200 Building	47.435	-122.282	W2	1956	-	1956	UBC	Yes	No		NO	C	469.0	No	No	No	Yes
Highline	Chinook Middle School	55063	300 Building - Gymnasium	47.435	-122.282	W2	1956	-	1955	UBC	Yes	No		NO	C	469.0	No	No	No	Yes
Highline	Chinook Middle School	55066	400 Building - Cafeteria	47.435	-122.282	W2	1956	-	1955	UBC	Yes	No		NO	C	469.0	No	No	No	Yes
Highline	Chinook Middle School	55064	800 Building	47.435	-122.282	W2	1966	-	1964	UBC	Yes	No		NO	C	469.0	No	Yes	No	Yes
Highline	Hilltop Elementary School	55177	100 Building - Bldg A	47.494	-122.302	RM1	1957	1989	1955	UBC	Yes	No		NO	D	332.9	No	Yes	Yes	Yes
Highline	Hilltop Elementary School	55176	200 Building - Bldg B	47.494	-122.302	W2	1957	-	1954	UBC	Yes	No		NO	D	332.9	No	No	No	Yes
Highline	Hilltop Elementary School	55178	300 Building - Bldg C	47.494	-122.302	W2	1958	-	1954	UBC	Yes	No		NO	D	332.9	No	No	No	Yes
Highline	Hilltop Elementary School	55175	400 Building - Bldg D	47.494	-122.302	W2	1998	-	1994	UBC	Yes	No		NO	D	332.9	No	No	No	Yes
Highline	Seahurst Elementary School	55100	Main Building	47.472	-122.353	W2	1992	-	1988	UBC	Yes	No		NO	C	504.0	No	No	No	Yes
Highline	Southern Heights Elementary School	55185	Building A	47.502	-122.315	W2	1955	1987	1954	UBC	Yes	Yes	1987	NO	D	358.0	No	No	No	Yes
Highline	Southern Heights Elementary School	55186	Building B	47.502	-122.315	W2	1956	1987	1954	UBC	Yes	Yes	1987	NO	D	358.0	No	No	No	Yes
Highline	Southern Heights Elementary School	55188	Building C - Admin/Multi Purpose	47.502	-122.315	RM1	1964	1987	1961	UBC	Yes	No	1987	NO	D	358.0	No	Yes	No	Yes
Highline	Sylvester Middle School	55128	100 Building	47.458	-122.341	W2	1953	-	1952	UBC	Yes	No		NO	D	293.3	No	Yes	Yes	Yes
Highline	Sylvester Middle School	55131	200 Building	47.458	-122.341	C2a	1953	-	1952	UBC	Yes	No		NO	D	293.3	No	No	No	Yes
Highline	Sylvester Middle School	55134	300 Building - Gymnasium/Cafeteria	47.458	-122.341	C2a	1953	1969	1952	UBC	Yes	No		NO	D	293.3	No	No	No	Yes

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Highline	Sylvester Middle School	55130	400 Building	47.458	-122.341	C2a	1953	-	1952	UBC	Yes	No		NO	D	293.3	No	Yes	No	Yes
Highline	Sylvester Middle School	55133	500 Building - Library	47.458	-122.341	C2a	1969	-	1967	UBC	Yes	No		NO	D	293.3	No	No	Yes	Yes
Highline	Sylvester Middle School	55129	600 Building	47.458	-122.341	C2a	1969	-	1967	UBC	Yes	No		NO	D	293.3	No	No	No	Yes
Highline	Sylvester Middle School	55132	700 Building - Band/Drama	47.458	-122.341	C2a	1969	-	1967	UBC	Yes	No		NO	D	293.3	No	No	Yes	Yes
Hockinson	Hockinson Heights Elementary School (East)	58331	Building 100 A	45.741	-122.467	RM1	1992	-	1988	UBC	Partial	No		NO	D	359.0	No	No	No	Yes
Hockinson	Hockinson Heights Elementary School (East)	58332	Building 200 C	45.741	-122.467	W2	1975	1992	1988	UBC	Partial	No		NO	D	359.0	No	No	No	Yes
Hockinson	Hockinson Heights Elementary School (East)	58328	Building 300 D	45.741	-122.467	W2	1975	1992			Partial	No		NO	D	359.0	No	No	No	Yes
Hockinson	Hockinson Heights Elementary School (East)	58326	Building 400 B	45.741	-122.467	W2	1992	-	1988	UBC	Partial	No		NO	D	359.0	No	Yes	No	Yes
Hockinson	Hockinson Heights Elementary School (East)	58327	Building 500 E	45.741	-122.467	W2	1980	2000	1976	UBC	Partial	No		NO	D	359.0	No	No	No	Yes
Hockinson	Hockinson Heights Elementary School (East)	58329	Building 600 F	45.741	-122.467	W2	1980	2000	1976	UBC	Partial	No		NO	D	359.0	No	No	No	Yes
Hockinson	Hockinson Heights Elementary School (East)	58325	Building 800 H	45.741	-122.467	W2	1975	2000	1973	UBC	Partial	No		NO	D	359.0	No	No	No	Yes
Hoquiam	Central Elementary School	58356	Main Building	46.980	-123.889	C2	1952	2000	1949	UBC	Partial	No		YES	E	168.4	No	No	Yes	Yes
Hoquiam	Emerson Elementary School	58357	Main Building	46.981	-123.904	C2	1954	2002	1952	UBC	Partial	No		YES	E	130.8	Yes	No	Yes	Yes
Hoquiam	Hoquiam High School	58347	D-Business Education	46.983	-123.910	W2	1966	-	1961	UBC	Partial	No		YES	D	242.0	No	No	Yes	Yes
Hoquiam	Hoquiam High School	58345	F-Humanities	46.983	-123.910	W2	1966	-	1961	UBC	Partial	No		YES	D	242.0	No	No	Yes	Yes
Hoquiam	Hoquiam High School	58346	G-Little Theater	46.983	-123.910	RM1	1966	-	1961	UBC	Partial	No		YES	D	242.0	No	No	No	Yes
Kelso	Coweeman Middle School	58393	Main Building	46.144	-122.889	W2	1961	-			Yes	No		NO	E	111.8	No	No	No	Yes
Kelso	Rose Valley Elementary School	58396	Main Building	46.098	-122.827	URM	1939	1984			Yes	No		NO	C	423.0	No	No	No	Yes
La Center	La Center Elementary & Middle Schools	50901	Building 300 - ES Main Building	45.861	-122.664	W2	1938	2004			Yes	No		NO	D	353.0	Yes	No	No	Yes
Lake Washington	Dickinson Elementary School	55935	Main Building	47.669	-122.062	W2	1992	-	1988	UBC	Yes	No		NO	C	499.3	No	No	No	Yes
Lake Washington	Einstein Elementary School	55836	Main Building	47.702	-122.098	S2a	1997	-	1991	UBC	Yes	No		NO	C	450.0	No	No	No	Yes
Lake Washington	Emerson Campus	55920	Emerson	47.656	-122.194	W2	1982	-	1979	UBC	Yes	No	1997	NO	D	341.3	No	No	No	Yes
Lake Washington	Rockwell Elementary School	55771	Main Building	47.699	-122.126	RM1	1986	-	1976	UBC	Yes	No		NO	D	353.3	No	No	No	Yes
Lake Washington	Wilder Elementary School	55846	Main Building	47.719	-122.041	W2	1989	-	1985	UBC	Yes	No		NO	C	549.8	No	No	No	Yes
Longview	Mint Valley Elementary School	58459	Building A - 1	46.166	-122.974	RM1	1969	-			Yes	No		YES	E	159.0	No	No	No	Yes
Longview	Mint Valley Elementary School	58458	Building B - 2	46.166	-122.974	RM1	1969	-			Yes	No		YES	E	159.0	No	No	No	Yes
Longview	Mint Valley Elementary School	58461	Building D - 4	46.166	-122.974	RM1	1969	-			Yes	No		YES	E	159.0	No	No	No	Yes

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Longview	Mt. Solo Middle School	58466	Main Building	46.165	-123.020	RM1	2003	-			Yes	No		YES	E	142.0	No	No	No	Yes
Longview	Northlake Elementary School	58447	Main Building	46.145	-122.944	W2	1954	-			No	No		NO	D-E*	#N/A	No	No	No	Yes
Longview	Olympic Elementary School	58438	Annex Building	46.139	-122.962	W2	1958	-			No	No		NO	E	159.0	No	No	No	Yes
Longview	Olympic Elementary School	58436	Main Building	46.139	-122.962	W2	1950	-			No	No		NO	E	159.0	No	No	No	Yes
Longview	Olympic Elementary School	58437	Multipurpose Building	46.139	-122.962	RM1	1958	-			No	No		NO	E	159.0	No	No	No	Yes
Longview	Robert Gray Elementary School	58432	Main Building	46.171	-122.993	RM2	1997	-	1994	UBC	Yes	No		YES	E	119.0	No	Yes	No	Yes
Lopez Island	Lopez Elementary School	56065	Elementary	48.492	-122.897	W2	1978	-			Yes	No		NO	C	413.4	No	No	No	Yes
Lopez Island	Lopez Middle High School	56067	Gym/Tech Building	48.492	-122.899	RM1	1988	-			Yes	No		NO	C	413.4	No	No	No	Yes
Lopez Island	Lopez Middle High School	56068	Junior Senior High Building	48.492	-122.899	W2	1930	-			No	No		NO	C	413.4	No	No	No	Yes
Mary M Knight	Mary M. Knight School	50921	Elementary School	47.199	-123.432	W2	1963	-	1961	UBC	Yes	No		NO	C	427.0	No	No	No	Yes
Mary M Knight	Mary M. Knight School	50924	High School Building	47.199	-123.432	W2	1979	-	1976	UBC	Yes	No		NO	C	427.0	No	No	No	Yes
Marysville	Cascade Elementary School	56103	Unit A	48.085	-122.160	RM1, W2	1955	-			Yes	Yes	1972	NO	D	288.8	No	No	No	Yes
Marysville	Cascade Elementary School	56101	Unit B	48.085	-122.160	RM1, W2	1955	-			Yes	No		NO	D	288.8	No	No	No	Yes
Marysville	Cascade Elementary School	56104	Unit C	48.085	-122.160	RM1, W2	1956	-	1955	UBC	Yes	Yes	1972	NO	D	288.8	No	No	No	Yes
Marysville	Cascade Elementary School	56102	Unit D	48.085	-122.160	RM1, W2	1956	-			Yes	Yes	1972	NO	D	288.8	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56254	Arts & Crafts Building - Bldg B	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56248	Auditorium - Bldg K	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	Yes	No	Yes	Yes
Marysville	Marysville Pilchuck Senior High School	56242	Business Ed & Home Learning - Bldg C	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56240	East Building - Bldg H	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56246	Gym & New Food Commons - Bldg M	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56244	Library - Bldg J	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	Yes	Yes	Yes
Marysville	Marysville Pilchuck Senior High School	56253	Life Science Building - Bldg F	48.096	-122.155	RM1	1970	-	1967	UBC	No	No		NO	D	304.0	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56235	Mech Plant & Former Cafeteria - Bldg E	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56245	Occupational Center - Bldg A	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	No	No	Yes
Marysville	Marysville Pilchuck Senior High School	56233	Pool Building - Bldg L	48.096	-122.155	RM1	1970	-	1967	UBC	Yes	No		NO	D	304.0	No	No	Yes	Yes
Marysville	Marysville Pilchuck Senior High School	56247	South Building - Bldg N	48.096	-122.155	RM1	1984	-			No	No		NO	D	304.0	No	No	No	Yes
Marysville	Pinewood Elementary School	56134	Bldg E	48.073	-122.162	RM1	1968	-			Yes	No		NO	D	243.9	No	No	No	Yes
Marysville	Pinewood Elementary School	56141	Bldg L (Library)	48.073	-122.162	RM1	1968	-			Yes	No		NO	D	243.9	No	No	No	Yes

District Name	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renov.	Bldg. Code Year	Bldg. Code	Struct. Dwgs. Avail.? (Yes, No, Partial)	Had Struct. Upgrade?	Year of Struct. Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Severe Vertical Irregularity	Moderate Vertical Irregularity	Horizontal Irregularity	ASCE 41 Tier 1
Marysville	Pinewood Elementary School	56139	Bldg M (Gym)	48.073	-122.162	RM1	1968	-			Yes	No		NO	D	243.9	No	No	No	Yes
Marysville	Pinewood Elementary School	56135	Building A	48.073	-122.162	RM1	1968	-			Yes	No		NO	D	243.9	No	No	No	Yes
Marysville	Pinewood Elementary School	56142	Building D	48.073	-122.162	RM1	1968	-			Yes	No		NO	D	243.9	No	No	No	Yes
Marysville	Quil Ceda Tulalip Elementary School	56204	Main Building	48.064	-122.199	W2	1997	-	1991	UBC	Yes	No		NO	D	263.0	No	No	Yes	Yes
Marysville	Shoultes Elementary School	56264	Bldg B (A Bldg in ICOS)	48.118	-122.162	RM1	1958	-	1961	UBC	Yes	No		NO	D	252.9	No	No	No	Yes
Marysville	Shoultes Elementary School	56266	Bldg A Gym (B Bldg in ICOS)	48.118	-122.162	RM1	1964	-			Yes	No		NO	D	252.9	No	No	No	Yes
Marysville	Shoultes Elementary School	56265	Bldg D (C Bldg in ICOS)	48.118	-122.162	RM1	1964	-			Yes	No		NO	D	252.9	No	No	No	Yes
Marysville	Shoultes Elementary School	56267	Bldg C (D Bldg in ICOS)	48.118	-122.162	RM1	1967	-	1961	UBC	Yes	No		NO	D	252.9	No	No	No	Yes
Mount Baker	Acme Elementary School	56410	Main Building	48.719	-122.209	W2	1937	-			No	No		NO	D	207.5	No	Yes	Yes	Yes
Napavine	Napavine Elementary School	58512	Main Building	46.578	-122.905	W2	1951	-			Yes	No		NO	C	374.7	No	No	No	Yes
Napavine	Napavine Junior Senior High School	58513	Annex	46.577	-122.904	W2	1955	-			Yes	No		NO	C	374.7	No	No	No	Yes
Napavine	Napavine Junior Senior High School	58514	Main	46.577	-122.904	S2a	1980	-			Yes	No		NO	C	374.7	No	No	No	Yes
Naselle-Grays River Valley	Naselle K-12 School	51032	High School/Admin	46.377	-123.801	W2	1952	1995			Partial	No		NO	D	301.0	No	Yes	No	Yes
Naselle-Grays River Valley	Naselle K-12 School	51032	Elementary	46.377	-123.801	W2	1952	1995			Yes	No		NO	D	301.0	No	No	No	Yes
North Beach	North Beach Junior/Senior High School	58529	Main Building	47.019	-124.158	RM1	1991	-	1988	UBC	Yes	No		YES	D	256.0	No	Yes	No	Yes
North Mason	Belfair Elementary School	58613	Gymnasium Building	47.439	-122.834	RM1	1970	-	1967	UBC	Yes	No		NO	C	376.0	No	No	No	Yes
North Mason	Belfair Elementary School	58614	Main Building	47.439	-122.834	RM2	1970	-	1967	UBC	Yes	No		NO	C	376.0	No	Yes	Yes	Yes
North River	North River School	58630	Elementary	46.775	-123.484	W2	1945	-			No	No		NO	D	311.0	No	No	No	Yes
North River	North River School	58634	Gym Home Ec-Cafeteria	46.775	-123.484	W2	1922	-			No	No		NO	D	311.0	No	No	No	Yes
North River	North River School	58631	High School & Admin Building	46.775	-123.484	W2	1922	-			No	No		NO	D	311.0	No	No	No	Yes
North River	North River School	58636	Talley Building (Music/Art)	46.775	-123.484	W2	1945	-			No	No		NO	D	311.0	No	No	No	Yes
Northshore	Canyon Creek Elementary School	56750	Building A - Classroom/Library	47.805	-122.188	RM1	1977	-			Yes	No		NO	C	431.0	No	No	No	Yes
Northshore	Canyon Creek Elementary School	56753	Building C - Cafeteria/Gym	47.805	-122.188	RM1	1977	-	1973	UBC	Yes	No		NO	C	431.0	No	No	No	Yes
Northshore	Crystal Springs Elementary School	56775	Building 1 - Admin	47.801	-122.220	RM1	1957	-			Yes	Yes	2010	NO	D	358.0	No	No	Yes	Yes
Northshore	Crystal Springs Elementary School	56774	Building 2 - Classrooms/Kitchen	47.801	-122.220	RM1	1957	-			Yes	Yes	2010	NO	D	358.0	No	No	Yes	Yes
Northshore	Crystal Springs Elementary School	56772	Building 3/4 - Classrooms	47.801	-122.220	RM1	1957	-			Yes	Yes	2010	NO	D	358.0	No	No	Yes	Yes
Northshore	Crystal Springs Elementary School	56770	Building 5 - Classrooms	47.801	-122.220	RM1	1957	-			Yes	Yes	2010	NO	D	358.0	No	No	No	Yes
Northshore	Shelton View Elementary School	56732	Building A1/10 - Classroom	47.786	-122.240	RM1	1969	1989	1967	UBC	Yes	No		NO	C	431.8	No	No	Yes	Yes
Northshore	Shelton View Elementary School	56727	Building C - Gym	47.786	-122.240	RM1	1969	1992	1967	UBC	Yes	No		NO	C	431.8	No	No	No	Yes

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Oak Harbor	Clover Valley School	51299	Main Building	48.329	-122.674	W2	1951	2000			Yes	No		NO	D	311.0	No	No	Yes	Yes
Oak Harbor	Oak Harbor Middle School	51291	Band Building	48.294	-122.659	RM1	1959	-			Yes	No		NO	C	499.0	No	No	No	Yes
Oak Harbor	Oak Harbor Middle School	51288	Building B	48.294	-122.659	W2	1961	1999			Yes	Yes	1999	NO	C	499.0	No	No	Yes	Yes
Oak Harbor	Oak Harbor Middle School	51290	C Wing	48.294	-122.659	W2	1961	1999			Yes	Yes	1999	NO	C	499.0	No	No	Yes	Yes
Oak Harbor	Oak Harbor Middle School	51294	D Wing	48.294	-122.659	W2	1948	1983			Yes	No		NO	C	499.0	No	No	No	Yes
Oak Harbor	Oak Harbor Middle School	51293	Gym	48.294	-122.659	RM1	1959	-			Yes	Yes	1999	NO	C	499.0	No	No	No	Yes
Oak Harbor	Oak Harbor Middle School	51289	Main Building A	48.294	-122.659	W2	1955	1999			Yes	Yes	1999	NO	C	499.0	No	No	Yes	Yes
Ocean Beach	Kaino Gym	58644	Kaino Gym	46.310	-124.039	W2	1885	-			No	No		NO	D	184.0	No	No	No	Yes
Olympia	Boston Harbor Elementary School	58698	Main Building	47.138	-122.886	W2	1991	-	1988	UBC	Yes	No		NO	C	444.4	No	No	No	Yes
Olympia	Thurgood Marshall Middle School	58671	Gym Building	47.062	-122.951	RM1	1994	-	1991	UBC	Yes	No		NO	C	454.7	No	No	No	Yes
Olympia	Thurgood Marshall Middle School	58672	Main Building	47.062	-122.951	W2	1994	-	1991	UBC	Yes	No		NO	C	454.7	No	No	No	Yes
Orting	Orting Primary School	58761	Main Building	47.101	-122.207	W2	1968	-	1964	UBC	Yes	No		NO	D	267.0	No	Yes	Yes	Yes
Pe Ell	Pe Ell School	51320	Fitness Center	46.575	-123.300	W2	1993	-			Partial	No		NO	C	388.4	No	No	No	Yes
Pe Ell	Pe Ell School	51321	Main Building	46.575	-123.300	URM	1954	2006			Partial	No		NO	C	388.4	No	Yes	No	Yes
Peninsula	Discovery Elementary School	58839	Main Building	47.332	-122.604	PC1	1980	1988	1976	UBC	Yes	No		NO	C	397.0	No	No	No	Yes
Peninsula	Gig Harbor High School	58821	Main Building	47.331	-122.605	RM1	1978	1991	1973	UBC	Yes	No		NO	C	397.0	No	Yes	No	Yes
Peninsula	Gig Harbor High School	58819	Two-Story Building	47.331	-122.605	W2	1991	-	1988	UBC	Partial	No		NO	C	397.0	No	No	Yes	Yes
Peninsula	Gig Harbor High School	58820	Voc-Ed Building	47.331	-122.605	RM1	1978	1982	1973	UBC	Partial	No		NO	C	397.0	No	No	No	Yes
Peninsula	Minter Creek Elementary School	58834	Main Building	47.373	-122.693	W2	1981	-	1979	UBC	Yes	No		NO	C	401.0	No	No	No	Yes
Peninsula	Peninsula High School	58793	500 Building	47.386	-122.624	W2	1946	1981			Partial	No		NO	C	368.0	No	No	No	Yes
Peninsula	Peninsula High School	58795	600 Building	47.386	-122.624	W2	1962	1981			Partial	No		NO	C	368.0	No	No	No	Yes
Peninsula	Peninsula High School	58791	700 Building - Voc Ag	47.386	-122.624	PC1	1978	-			Partial	No		NO	C	368.0	No	No	No	Yes
Peninsula	Peninsula High School	58792	800 Building - Auditorium Area	47.386	-122.624	W2	1970	1992			Partial	No		NO	C	368.0	No	No	No	Yes
Peninsula	Peninsula High School	58794	900 Building - Pool Building	47.386	-122.624	W2	1969	1992			Partial	No		NO	C	368.0	No	No	No	Yes
Peninsula	Peninsula High School	58796	Main Building (100, 200, 300, 400)	47.386	-122.624	W2	1946	1992			Partial	No		NO	C	368.0	No	No	No	Yes
Peninsula	Voyager Elementary School	58817	Main Building	47.309	-122.679	W2	1988	-	1985	UBC	Yes	No		NO	D	323.3	No	No	No	Yes
Port Townsend	Blue Heron Middle School	58917	Main Building	48.129	-122.779	CFS2	1995	-	1991	UBC	Yes	No		NO	D	350.0	No	No	Yes	Yes
Puyallup	Meeker Elementary School	59062	Main Building	47.188	-122.299	W2	1923	1979			Yes	No		NO	E	171.0	No	No	No	Yes
Puyallup	Mt View Elementary School	58954	Main Building	47.226	-122.271	W2	1965	1991	1961	UBC	Yes	No		NO	C	499.8	No	No	No	Yes
Puyallup	Mt View Elementary School	58954	Multipurpose Building	47.226	-122.271	RM1	1965	1991	1961	UBC	Yes	No		NO	C	499.8	No	No	No	Yes

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Puyallup	Waller Road Elementary School	59011	Main Building	47.199	-122.389	URM	1936	1985			Yes	Yes	1985	NO	C	554.0	No	No	No	Yes
Puyallup	Wildwood Elementary	58921	Main Building	47.166	-122.274	W2	1965	1991	1961	UBC	Yes	No		NO	C	504.2	No	No	No	Yes
Quillayute Valley	Forks Elementary School	59199	Main Building - 1969 Portion	47.948	-124.379	W2	1970	1989			No	No		NO	C	419.0	No	No	No	Yes
Quillayute Valley	Forks Intermediate School	59203	Main Building - 1952 Portion	47.949	-124.384	W2	1956	1989			No	No		NO	C	419.0	No	Yes	Yes	Yes
Quillayute Valley	Forks Junior-Senior High School	59193	Main Junior High Building - 1949 Portion	47.948	-124.384	W2	1949	-			No	No		NO	C	419.0	No	No	No	Yes
Renton	Hazen Senior High School	56887	700 Building	47.501	-122.153	PC1a	1968	-	1964	UBC	Yes	No		NO	C	376.0	No	No	Yes	Yes
Renton	Hazen Senior High School	56888	Bldg 1 Gym/Pool	47.501	-122.153	PC1a	1969	-	1964	UBC	Yes	No		NO	C	376.0	No	No	Yes	Yes
Renton	Hazen Senior High School	56888	Bldg 1 Main Building	47.501	-122.153	PC1a	1969	2002	1964	UBC	Yes	No		NO	C	376.0	No	Yes	Yes	Yes
Renton	Hazen Senior High School	56888	Bldg 1 Music, Band, Cafeteria	47.501	-122.153	PC1a	1969	2002	1964	UBC	Yes	No		NO	C	376.0	No	Yes	Yes	Yes
Renton	Hazen Senior High School	56885	Gym Addition	47.501	-122.153	C2a	1977	-	1973	UBC	Yes	No		NO	C	376.0	No	Yes	Yes	Yes
Renton	Lindbergh Senior High School	56944	Gym Addition	47.455	-122.167	RM1	1979		1973	UBC	Yes	No		NO	C	396.7	No	No	Yes	Yes
Renton	Lindbergh Senior High School	56944	Gymnasium	47.455	-122.167	RM1	1971	2010	1967	UBC	Yes	Yes	2010	NO	C	396.7	Yes	No	Yes	Yes
Renton	Lindbergh Senior High School	56945	Main Building - North	47.455	-122.167	RM1	1971	2003	1967	UBC	Yes	No		NO	C	396.7	Yes	No	Yes	Yes
Renton	Lindbergh Senior High School	56945	Main Building - South	47.455	-122.167	RM1	1971	2003	1967	UBC	Yes	No		NO	C	396.7	No	Yes	Yes	Yes
Renton	Renton Senior High School	56901	Cafeteria/Gym	47.482	-122.212	C2a	1954	2002	1952	UBC	Yes	Yes	2002	NO	D	272.0	No	Yes	Yes	Yes
Ridgefield	South Ridge Elementary School	59234	Main Building	45.766	-122.675	S5a	1961	1993			No	No		NO	D	316.0	No	No	No	Yes
Skamania	Skamania Elementary School	59377	Main Building	45.617	-122.049	W2	1947	-			Partial	No		NO	D	319.0	No	No	No	Yes
Snohomish	Cathcart Elementary School	57090	100 Building	47.827	-122.122	RM1	1966	-			No	No		NO	C	474.0	No	No	Yes	Yes
Snohomish	Cathcart Elementary School	57091	200 Building	47.827	-122.122	RM1	1966	-			No	No		NO	C	474.0	No	No	Yes	Yes
Snohomish	Cathcart Elementary School	57089	300 Building	47.827	-122.122	RM1	1966	-			No	No		NO	C	474.0	No	No	Yes	Yes
Snohomish	Cathcart Elementary School	57088	400 Building	47.827	-122.122	RM1	1966	-			No	No		NO	C	474.0	No	Yes	No	Yes
Snohomish	Cathcart Elementary School	57092	500 Building	47.827	-122.122	RM1	1980	-			No	No		NO	C	474.0	No	No	No	Yes
Snohomish	Cathcart Elementary School	57094	600 Building	47.827	-122.122	RM1	1966	-			No	No		NO	C	474.0	No	No	Yes	Yes
Snohomish	Cathcart Elementary School	57093	700 Building	47.827	-122.122	RM1	1970	-			No	No		NO	C	474.0	No	No	Yes	Yes
Snohomish	Central Elementary School	57085	Main Building	47.914	-122.092	C2a, W2	1948	-			No	No		NO	C	438.0	No	Yes	Yes	Yes
Snohomish	Emerson Elementary School	57133	Annex	47.925	-122.084	W2	1958	-			No	No		NO	C	527.6	No	No	No	Yes
Snohomish	Emerson Elementary School	57132	Main Building	47.925	-122.084	W2	1954	-			No	No		NO	C	527.6	No	No	No	Yes
South Bend	South Bend Jr/Sr High School	51397	Main Building High School	46.662	-123.792	W2	1968	2010	1964	UBC	No	No		YES	E	109.0	No	No	No	Yes
South Whidbey	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57247	A- Classrooms	48.026	-122.456	RM1	1969	-			No	No		NO	C	460.0	No	No	No	Yes
South Whidbey	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57245	C - Classrooms/Admin	48.026	-122.456	RM1	1969	-			No	No		NO	C	460.0	No	No	No	Yes

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South Whidbey	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57249	D - WIA Office/Classrooms	48.026	-122.456	RM1	1969	-			Partial	Yes	1996	NO	C	460.0	No	No	No	Yes
South Whidbey	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57250	E - Classrooms	48.026	-122.456	RM1	1969	-			Partial	Yes	1996	NO	C	460.0	No	Yes	No	Yes
South Whidbey	South Whidbey Grades 5 & 6 - (Formerly S. Whid. Primary)	57248	F - Multipurpose	48.026	-122.456	W2	1969	-			Yes	Yes	1996	NO	C	460.0	No	Yes	Yes	Yes
Spokane	Bancroft (The Community School)	53586	Main Building	47.672	-117.428	URM	1954	-	1958	UBC	Yes	No		NO	C	461.0	No	No	No	Yes
Spokane	Bryant Center	53558	Main Building	47.665	-117.437	RM1	1960	-			Yes	No		NO	C	389.0	No	No	No	Yes
Spokane	Havermale (Montessori)	53500	Main Building 1928 & 1940 Areas	47.677	-117.432	URMa	1928	-			No	No		NO	C	449.0	No	Yes	No	Yes
Spokane	Havermale (Montessori)	53500	Main Building 1928 Gym	47.677	-117.432	URM	1928	-			No	No		NO	C	449.0	No	No	No	Yes
Spokane	Havermale (Montessori)	53500	Main Building 1965 Areas	47.677	-117.432	URM	1928	-			Yes	No		NO	C	449.0	No	Yes	No	Yes
Spokane	Madison Elementary School	53579	Main Building	47.709	-117.416	URM	1948	-			Yes	No		NO	D	328.8	No	No	No	Yes
Stanwood-Camano	Stanwood Elementary School	51456	Main Building Unit C 1966	48.245	-122.372	W2	1966		1964	UBC	Yes	Yes	1995	YES	E	176.0	No	No	No	Yes
Stanwood-Camano	Stanwood Elementary School	51456	Main Building Unit C 1981	48.245	-122.372	W2	1981		1979	UBC	Yes	No		YES	E	176.0	No	No	Yes	Yes
Stanwood-Camano	Stanwood Elementary School	51456	Main Building Units A, B	48.245	-122.372	W2	1956	1996	1952	UBC	Yes	Yes	1995	YES	E	176.0	No	No	No	Yes
Stanwood-Camano	Stanwood Middle School	51449	Building 3 - Music (Band & Choir)	48.242	-122.361	RM1	1957	1992			Yes	No		YES	E	163.0	No	No	No	Yes
Stanwood-Camano	Stanwood Middle School	51448	Main Building (Building 1) Unit D	48.242	-122.361	S2a	1992		1988	UBC	Yes	No		YES	E	163.0	No	No	No	Yes
Stanwood-Camano	Stanwood Middle School	51448	Main Building (Building 1) Unit G	48.242	-122.361	W2	1989		1985	UBC	Yes	No		YES	E	163.0	No	No	No	Yes
Stanwood-Camano	Stanwood Middle School	51448	Main Building (Building 1) Units E & F	48.242	-122.361	RM1	1968		1967	UBC	Yes	No	2019	YES	E	163.0	No	No	No	Yes
Stanwood-Camano	Twin City Elementary School	51411	Main Building	48.235	-122.329	S2a	1988	-	1985	UBC	Yes	No		NO	D	300.0	No	Yes	No	Yes
Stevenson-Carson	Carson Elementary School	59495	Main Building	45.726	-121.813	W2	1951	-			Yes	No		NO	C	419.1	No	No	No	Yes
Stevenson-Carson	Stevenson High School	59488	Main Building	45.701	-121.887	W2	1954				Yes	No		NO	D	270.0	No	No	No	Yes
Stevenson-Carson	Stevenson High School	59491	Vocational Building	45.701	-121.887	RM1	1964	-			Yes	No		NO	D	270.0	No	No	No	Yes
Stevenson-Carson	Wind River Education Center	59499	Main Building	45.726	-121.811	PC1	1970	1985			Yes	No		NO	C	419.1	No	No	No	Yes
Tacoma	DeLong Elementary School	59598	First Bldg-Bldg B	47.249	-122.501	W2	1958	1986			Yes	No		NO	C	443.0	No	No	No	Yes
Tacoma	DeLong Elementary School	59597	Original Bldg-Bldg A	47.249	-122.501	W2	1953	1986			Yes	No		NO	C	443.0	No	No	No	Yes
Tacoma	Edison Elementary School	59747	Main Building	47.204	-122.474	W2	1997	-	1994	UBC	Yes	No		NO	C	409.0	No	No	Yes	Yes
Tacoma	Foss High School	59802	Gym-Pool-Cafeteria	47.239	-122.495	RM1	1972	2005	1970	UBC	Yes	No		NO	C	432.0	No	No	No	Yes
Tacoma	Foss High School	59802	Main Building - 2003 Addition	47.239	-122.495	S2a	2003		1997	UBC	Yes	No		NO	C	432.0	No	No	No	Yes
Tacoma	Foss High School	59802	Main Building - North	47.239	-122.495	RM2	1972	2005	1970	UBC	Yes	No		NO	C	432.0	No	No	Yes	Yes

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Tacoma	Foss High School	59802	Main Building - South	47.239	-122.495	RM2	1972	2005	1970	UBC	Yes	No		NO	C	432.0	No	No	No	Yes
Tacoma	Franklin Elementary School	59589	Main Building	47.248	-122.479	RM1	1997	-	1991	UBC	Yes	No		NO	C	508.0	No	No	No	Yes
Tacoma	Larchmont Elementary School	59804	Original Building	47.178	-122.428	W2	1969	-	1964	UBC	Yes	No		NO	C	515.7	No	No	No	Yes
Tacoma	Lister Elementary School	59790	Main Building	47.216	-122.400	W2	1998	-	1994	UBC	Yes	No		NO	C	513.0	No	No	No	Yes
Tacoma	Manitou Park Elementary School	59601	Main Building	47.197	-122.495	W2	1994	-	1991	UBC	Yes	No		NO	C	391.2	No	No	Yes	Yes
Tacoma	Mann Elementary School	59664	Main Building	47.210	-122.448	W2	1952	-			Yes	No		NO	C	561.0	No	No	No	Yes
Tacoma	Northeast Tacoma Elementary School	59627	Gym Bldg-Bldg 2	47.282	-122.375	RM1	1993	-	1988	UBC	Yes	No		NO	C	453.9	No	No	No	Yes
Tacoma	Northeast Tacoma Elementary School	59626	Main Bldg-Bldg 1	47.282	-122.375	W2	1993	-	1988	UBC	Yes	No		NO	C	453.9	No	No	No	Yes
Tacoma	Point Defiance Elementary School	59730	Main Building	47.290	-122.518	W2	1959	1987			Yes	No		NO	C	428.0	No	No	No	Yes
Tacoma	Reed Elementary School	59628	Main Building	47.226	-122.461	W2	1950	1987			Yes	No		NO	C	439.0	No	No	No	Yes
Tacoma	Roosevelt Elementary School	59688	Main Bldg	47.228	-122.399	W2	1972	-			Yes	No		NO	C	562.2	No	No	No	Yes
Tacoma	Sheridan Elementary School	59723	Main Building	47.209	-122.420	W2	1993	-	1991	UBC	Yes	No		NO	C	541.0	No	No	Yes	Yes
Tacoma	Stanley Elementary School	59636	First Bldg	47.245	-122.460	W2	1989	-	1982	UBC	Yes	No		NO	C	452.0	No	No	No	Yes
Tacoma	Stanley Elementary School	59635	Gym Bldg	47.245	-122.460	RM1	1971	1989			Yes	No		NO	C	452.0	No	No	No	Yes
Tacoma	Tacoma School of the Arts-Pacific	59768	SOTA Pacific Ave	47.244	-122.437	URM	1904	-			Yes	No		NO	C	399.0	No	No	No	Yes
Tacoma	Willie Stewart Academy	59727	Main Bldg	47.245	-122.443	URM	1919	-			Yes	No		NO	C	549.0	No	No	No	Yes
Toledo	Toledo Elementary School	59838	Main Building	46.439	-122.853	RM1	1954	1995			Partial	No		NO	D	241.0	No	No	No	Yes
Toledo	Toledo Middle School	59842	Classroom Bldg. (Bldg #2)	46.441	-122.850	W2	1952	1996			Partial	No		NO	C	603.0	No	No	No	Yes
Toledo	Toledo Middle School	59844	Main Building (Bldg. #1)	46.441	-122.850	W2	1952	1996			Partial	No		NO	C	603.0	No	Yes	No	Yes
University Place	Curtis Senior High School	59969	500 Building	47.222	-122.550	RM1	1971	-	1970	UBC	Yes	No		NO	D	343.0	No	No	No	Yes
University Place	Sunset Primary School	59982	Main Building	47.216	-122.564	W2	1966	1993			Yes	No		NO	C	373.2	No	No	No	Yes
Wahkiakum	Julius A. Wendt Elementary/ John C. Thomas Middle School	53717	J A Wendt Elementary School	46.201	-123.380	W2	1952	1994			No	No		NO	C	396.0	No	No	No	Yes
West Valley (Yakima)	West Valley Junior High School	51547	WVJH (Gym Building)	46.578	-120.608	PC1a	1978	-			Yes	No		NO	C	428.9	No	No	No	Yes
West Valley (Yakima)	West Valley Junior High School	51546	WVJH (Main Building)	46.578	-120.608	RM2	1978	-			Yes	No		NO	C	428.9	No	No	No	Yes
White River	Mountain Meadow Elementary School	51616	Main Building	47.151	-122.059	W2	1990	-	1991	UBC	Yes	No		NO	C	398.8	No	No	Yes	Yes
Willapa Valley	Willapa Elementary School	60150	Main Building	46.676	-123.665	W2	1963	2012			Partial	No		NO	D	318.0	No	No	No	Yes
Woodland	Columbia Elementary School	60181	1991 Addition	45.903	-122.753	RM1	1993				No	No		NO	E	158.0	No	No	No	Yes
Woodland	Columbia Elementary School	60181	Main Building	45.903	-122.753	RM1	1972	1993			Partial	No		NO	E	158.0	No	Yes	No	Yes
Woodland	Woodland Middle School	60193	Gymnasium Building	45.904	-122.748	URM	1954	1983			Yes	No		NO	E	158.0	No	No	No	Yes
Woodland	Woodland Middle School	60193	Main Building	45.904	-122.748	URMa	1954	-			Partial	No		NO	E	158.0	No	No	No	Yes

District Name	Site Name	ICOS Bldg ID No.	Building Name	Latitude	Longitude	FEMA Const. Type	Year Built	Last Renov.	Bldg. Code Year	Bldg. Code	Struct. Dwgs. Avail.? (Yes, No, Partial)	Had Struct. Upgrade?	Year of Struct. Upgrade	Tsunami Risk	Vs30 Measured Site Class	Vs30 (m/s)	Severe Vertical Irregularity	Moderate Vertical Irregularity	Horizontal Irregularity	ASCE 41 Tier 1
Woodland	Woodland Middle School	60193	Performing Arts	45.904	-122.748	RM1	1954	-			Partial	No		NO	E	158.0	No	No	No	Yes
Woodland	Woodland Middle School	60192	Shared High School/ Middle School	45.904	-122.748	URM	1954	-			Partial	No		NO	E	158.0	No	No	No	Yes
Woodland	Woodland Middle School	60193	Vocational Building	45.904	-122.748	RM1	1954	-			Partial	No		NO	E	158.0	No	No	No	Yes
Yakima	Adams Elementary School	53952	8 Plex Bldg D	46.595	-120.490	URM	1971	-			Yes	No		NO	C	626.6	No	No	No	Yes
Yakima	Adams Elementary School	53950	BLDG C-1	46.595	-120.490	RM1	1960	-			Yes	No		NO	C	626.6	No	No	No	Yes
Yakima	Adams Elementary School	53953	Old Gym C	46.595	-120.490	RM1	1960	-			Yes	No		NO	C	626.6	No	No	No	Yes
Yakima	Hoover Elementary School	54025	Area D - Annex Building	46.581	-120.512	W2	1975	-			Partial	No		NO	C	636.0	No	No	No	Yes
Yakima	Hoover Elementary School	54021	Classrooms - Area F	46.581	-120.512	W2	1975	-			Partial	No		NO	C	636.0	No	No	No	Yes
Yakima	Hoover Elementary School	54023	Main Building - Area A	46.581	-120.512	W2	1948	-			Partial	No		NO	C	636.0	No	No	No	Yes
Yakima	Hoover Elementary School	54023	Main Building - Area B	46.581	-120.512	W2	1948	-			Partial	No		NO	C	636.0	No	No	No	Yes
Yakima	Nob Hill Elementary School	53961	Main Building	46.590	-120.553	URM	1951	1986			Yes	No		NO	C	434.0	No	No	No	Yes
Yakima	Robertson Elementary School	53918	100 Building - Bldg "B"	46.605	-120.547	RM1	1958	1990			Yes	No		NO	C	627.0	No	No	No	Yes
Yakima	Robertson Elementary School	53917	200 Building - Bldg "C"	46.605	-120.547	RM1	1958	1990			Yes	No		NO	C	627.0	No	No	No	Yes
Yakima	Robertson Elementary School	53919	300 Building - Bldg "D"	46.605	-120.547	RM1	1958	1990			Yes	No		NO	C	627.0	No	No	No	Yes
Yakima	Robertson Elementary School	53930	400 Building - Bldg "E"	46.605	-120.547	RM1	1958	1990			Yes	No		NO	C	627.0	No	No	No	Yes
Yakima	Robertson Elementary School	53920	500 Building - Bldg "G"	46.605	-120.547	RM1	1958	1990			Yes	No		NO	C	627.0	No	No	No	Yes
Yakima	Wilson Middle School	53968	Main Building	46.589	-120.567	URMa	1961	1996			Partial	No		NO	C	560.2	No	No	No	Yes
Yakima	Wilson Middle School	53969	Science Building	46.589	-120.567	URMa	1961	1996			Partial	No		NO	C	560.2	No	No	No	Yes

APPENDIX B.5: ECONOMIC CONSIDERATIONS

Prepared by ECONorthwest

B5.1 Introduction

Seismic retrofit needs across the state pose a daunting challenge for policymakers. Buildings vary in age and structural performance level, the timing and size of both seismic risk and potential project funding are uncertain, and government spending must be weighed against public benefits. Economics should be used as a tool to help decision-makers prioritize spending and maximize net benefits.

The Phase I report indicated that the majority of school buildings in Washington are expected to be “Red-Unsafe” in the event of a design-level earthquake, meaning that a majority of buildings require some level of retrofitting in order to ensure public safety. This Phase II report conducts additional analysis and design concept level assessments on costs and seismic risk. This analysis provides estimates of damage level under a variety of seismic events, replacement cost, and retrofitting costs. While this information is highly informative, further analysis should be conducted to also estimate the anticipated number of deaths and the duration of repairs. These are additional critical inputs that can assess the relative benefits of retrofitting versus replacement, and can help to guide decision-making around future public funding of seismic resiliency in public schools.

The Washington State Legislature has already prioritized seismic school retrofits by approving \$13.24 million in 2020 for retrofitting grants to the Office of Superintendent of Public Instruction (OSPI)³. These funds were directed to be prioritized for high risk and high deficiency buildings. Another \$39 million has been approved for the coming biennium to continue the retrofitting program. This report demonstrates the need for seismic upgrades and this chapter explains how economic analysis should be used to decide on the allocation of limited funding that maximizes benefits.

B5.2 The Role of Economics in Public Policy

Economics is a valuable tool to apply to public policy decisions because it allows policymakers to make informed decisions on the optimal allocation of scarce resources to maximize net benefits. Specifically, economics helps measure the impact of government infrastructure spending on the economy and the public.

Economics informs public policy in three dimensions:

- What are the changes in economic value? (i.e., benefits and costs, impacts to social welfare),
- What are the impacts to economic activity? (e.g., jobs, labor income, Gross Regional Product, output, etc.), and

³ Superintendent of Public Instruction Capital Project Request 2021-2023 Biennium. Pg. 44. Retrieved from: <https://www.k12.wa.us/sites/default/files/public/schfacilities/pubdocs/OSPI%20CBR%20FINAL.pdf>

- What are the distributional effects? (e.g., who receives benefits and who incurs the costs, what industries and employees experience increases or declines in economic activity?)

Barring sufficient funding to retrofit all schools in the state, decisions need to be made on which schools receive resources to improve seismic resiliency. These decisions affect the value communities receive from the investment, resulting economic impacts of spending, and the distributional welfare of individuals. A comprehensive economic analysis should evaluate all three of these dimensions to inform the full suite of potential economic effects from seismic retrofit decisions. Figure 1 displays how these three perspectives of analysis contribute to the core analysis of the effects of a policy relative to baseline conditions.

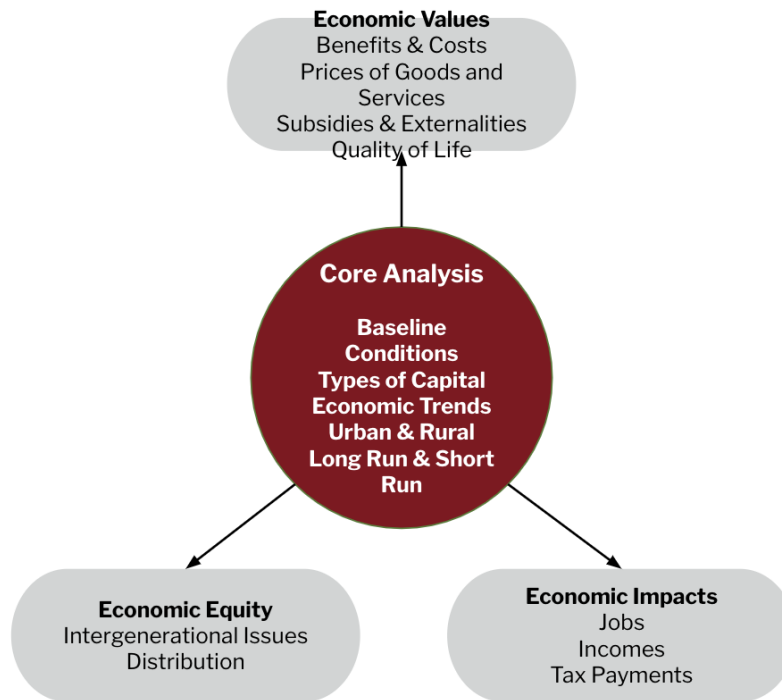


Figure 1: Economic Measures
Source: ECONorthwest

B5.2.1 Economic Impacts from Government Spending

Should the Legislature choose to spend funds on seismic upgrades or school building replacements, the money spent on this investment in infrastructure will circulate throughout the local economy. Not only will the community benefit from knowing their schools are safer in the event of a major earthquake, but the spending itself will result in increases in local income and jobs. This spending can cause several different types of positive local impacts, which are organized into three categories in economics: direct impacts, indirect impacts, and induced impacts.

- **Direct impacts** are the actual spending from the government on the project in the local economy, often measured in terms of jobs, and employee compensation by the investments in seismic resilience in Washington.
- **Indirect impacts** are the economic effects supported by the purchase of goods and services in the study region. When demand for goods and services increases, businesses may purchase more goods and hire additional staff to meet this increased demand. These are typically referred to as “supply chain” effects.
- **Induced impacts** are the changes in regional household spending patterns caused by changes in household income. For example, employees in the industries which experience increased economic activity from spending to retrofit schools may increase their household spending, leading to further economic activity. These are typically referred to as “consumption effects.”

This circulation of funding results in what is often called the “**multiplier effect**” in the local economy where the total effects of the government spending are often much larger than the initial investment. Some funding may leave the local economy too, and this is known as “**leakage**”. **Error! Reference source not found.** shows the impact of government expenditures on a local economy.

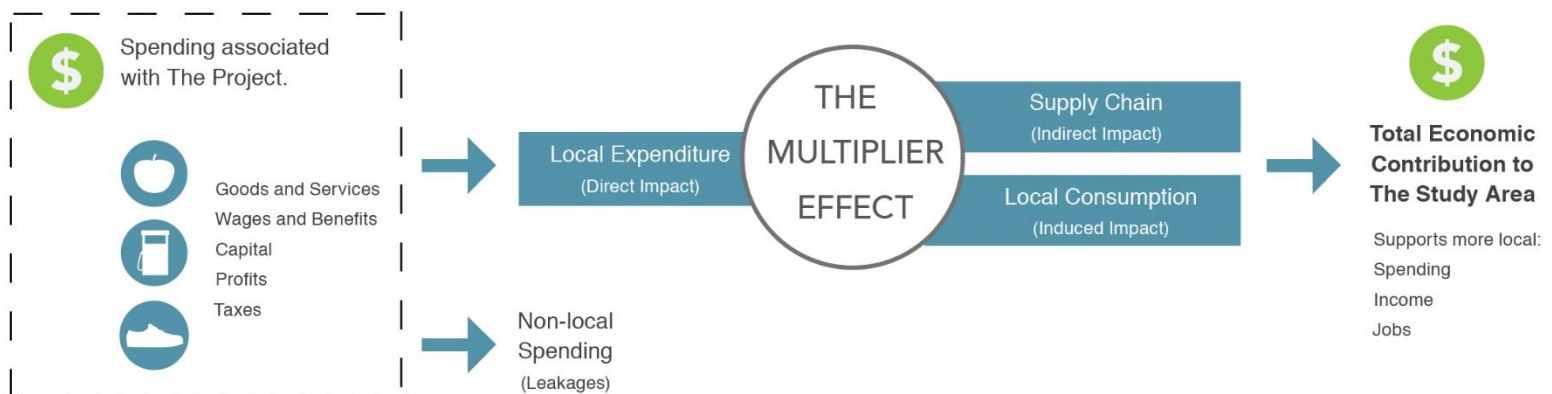


Figure 2: Economic Impact Analysis
Source: ECONorthwest

The net local economic impact of spending on seismic upgrades will depend on where labor and materials come from, and can be measured by economic impact modeling software. These models use local economic relationships to calculate how spending recirculates through the local economy. Input-output models work by tracing how spending associated with the business circulates through the economy of the study area. That is, changes in the amount produced by one or more sectors trigger changes in production and consumption throughout the economy. The initial, direct change in activity starts a flow of spending in the region, circulating around and around, with each successive round becoming smaller because of leakages out of the economy of the geographic area for the study.

Ultimately, seismic retrofits function as an economic investment in a community, and the output caused by this spending can be measured in terms of jobs, labor income, supply chain, and consumption effects.

B5.2.2 Public Value of Government Investment

Seismic school retrofits confer benefits to a community by knowing that children are safer and that school buildings can return to service sooner following a major earthquake. These benefits are known as “public goods” because although individuals may have a high value for them, they cannot be purchased in a store or supplied by a private market.⁴ Governments generally are responsible for providing many public goods that otherwise would not exist. While private schools provide options for parents seeking alternative learning environments, the community as a whole benefits from knowing that all children receive a high quality education in a safe learning environment, regardless of whether they have children of their own. This community benefit and responsibility puts the onus on the government to provide safe and effective schools.

Infrastructure investment through seismic retrofits not only reduces expected damage and increases safety to students in the builds, but also provides many other valuable outcomes including:

- **Disaster preparedness and emergency shelter during a seismic event.**

Following natural disasters, school buildings often serve as emergency shelters for displaced residents and staging areas for response efforts.⁵ For example, following Hurricane Irma, schools in Miami-Dade County served as emergency shelters for over 20,000 evacuees and their pets.⁶

- **Increase in property values.**

School quality, including safety, has long been understood to influence property values.⁷ The link between the quality of the education and facilities is also strong.⁸ Improvements in school facility safety can confer direct financial benefits to local homeowners, as public school quality is capitalized in property values as a local public good.

- **Resilient infrastructure that ensures uninterrupted education.**

A key outcome of seismic retrofits includes an expedited return to service of the building. Any investments that would reduce the time it takes for a community to recover from a major earthquake, including returning children to classrooms sooner, will provide benefits to the community and limit the resources necessary following the event.

These outcomes are public goods of value to the local community, which would be provided through the government investment in seismic upgrades.

⁴ Public goods are classically defined as being “non-rival” and “non-excludable,” meaning that the consumption of the good by one individual does not diminish the amount available for the next and that no single individual can be excluded from consuming that good.

⁵ <https://www.nea.org/advocating-for-change/new-from-nea/public-schools-offer-shelter-storm>

⁶ <https://www.miamiherald.com/news/weather/article173421646.html>

⁷ Hwang, J. W., Kuang, C., & Bin, O. (2019). Are all Homeowners Willing to Pay for Better Schools?— Evidence from a Finite Mixture Model Approach. *The Journal of Real Estate Finance and Economics*, 58(4), 638-655.

⁸ Lackney, J. A. (1999). Assessing School Facilities for Learning/Assessing the Impact of the Physical Environment on the Educational Process: Integrating Theoretical Issues with Practical Concerns.

B5.2.3 Distributional Impacts from Government Spending

When assessing the economic effects of a policy, the distributional impacts of government spending are also critical because many communities value equitable fairness and are willing to pay for it.

Any decisions made about seismic upgrade spending should be analyzed to ensure the distributional impacts of an action are improving social welfare for at least one person and are not resulting in any harm to another. Oftentimes, impacts on welfare vary depending on income level, region, economic opportunity, and other factors. Some historically disadvantaged portions of the population may disproportionately benefit from seismic school retrofits. When making decisions on where to spend seismic upgrading funds, distributional impacts must be assessed. Government spending can have a positive impact on vulnerable populations in this scenario, and there is an opportunity to utilize the multiplier effect to create larger social welfare impacts.

For example, an equitable policy may be one where seismic upgrades are performed on schools with both high seismic risk and a higher proportion of disadvantaged communities. In addition to providing direct public benefits, the spending would also drive economic development in those regions. Targeting historically disadvantaged groups can improve distributional outcomes on multiple dimensions.

B5.3 Economics and Decision Making: Replace, Retrofit, No Action

For each public school in the state, there are several alternatives to be evaluated when it comes to seismic risk. Assuming that the state does not want to permanently remove any schools from service, there are three most common options:

- Retrofit the existing building to a level that better protects life safety and limits property damage,
- Replace an existing building with a new building that protects life safety and limits property damage,
- Take no action and leave the building as is.

When making a policy decision, economics can help to evaluate these alternatives by organizing their impacts along the dimensions of costs and benefits. Projects fall along a spectrum from low to high for both costs and benefits, and economics should be used to measure and compare these outcomes. Depending on the desired policy outcome, a particular type or set of projects should be targeted. **Error! Reference source not found.** below shows how projects or alternatives can be organized by their benefits and costs in order to identify projects which are small in their impact, easy to implement and high in benefit, and projects which should not be undertaken.

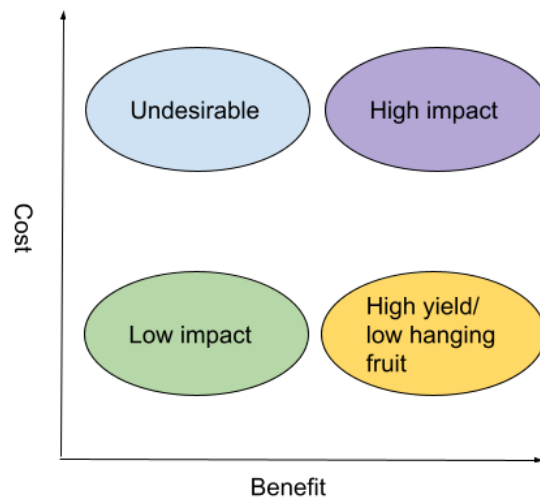


Figure 3: Project Types Based on Benefit/Cost Factors

Source: ECONorthwest

Economics allows the cost factors and benefits to be measured in equal terms and then easily compared. Components may not be obviously measurable, which is why economics uses a variety of tools to address the levels of ambiguity in cost and benefit factors. The primary tool used by economists to evaluate changes in value to society is Benefit-Cost Analysis.

B5.3.1 Benefit-Cost Analysis

At its most basic level, Benefit-Cost Analysis (BCA) is a tool for comparing alternatives. Done correctly, and recognizing its limitations, BCA provides a well-defined method for examining the value of an action and tradeoffs among different actions. Measuring benefits and costs over time helps to identify alternatives that maximize the net benefit.

This tool is useful because it captures a wide array of impacts and factors. Often the impacts of a project are unknown or only generally understood. BCA allows for less defined elements to be described qualitatively, and for elements that are more precise to be quantified and monetized. This flexibility is critical because many impacts which have real value are not easily monetized.

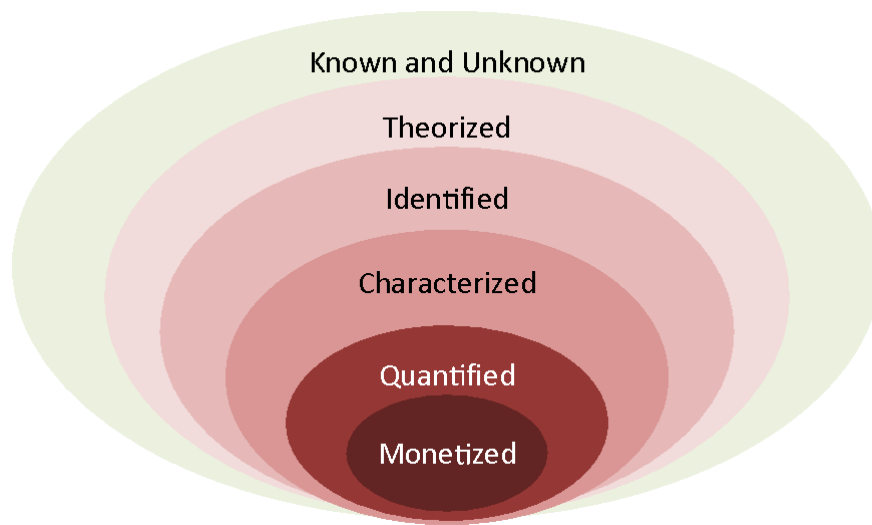


Figure 4: Full Array of Benefits and Costs

Source: ECONorthwest

Especially relevant for decisions involving uncertain seismic risk and long-term infrastructure investments, is the ability of BCA to measure costs and benefits over time. This considers the temporal effects of a project, including long term effects and annualized costs. BCA also evaluates the distributional effects on different populations. It considers not only what the benefits and costs are, but also to whom they accrue. Importantly for seismic preparedness planning, BCA also incorporates risk and uncertainty through discounting. A discount rate is used to adjust for uncertainty and to convert future dollars to present value.

In this decision-making scenario, there are several known outcomes that will be provided, including the number of deaths, expected repair time, and anticipated damage level. These can be used to quantify and monetize certain benefits and costs and identify those who will be affected by a seismic event. Other impacts may need to be evaluated qualitatively. This tool should help policymakers determine if the net benefits of retrofitting outweigh the costs in a variety of scenarios. It may also indicate if replacement or no action are more suitable alternatives. Generally speaking, any action which results in a benefit to cost ratio (BCR) greater than 1 is one

that should be taken as soon as possible. This is illustrated by the graph below which shows the 1:1 benefit cost ratio threshold.

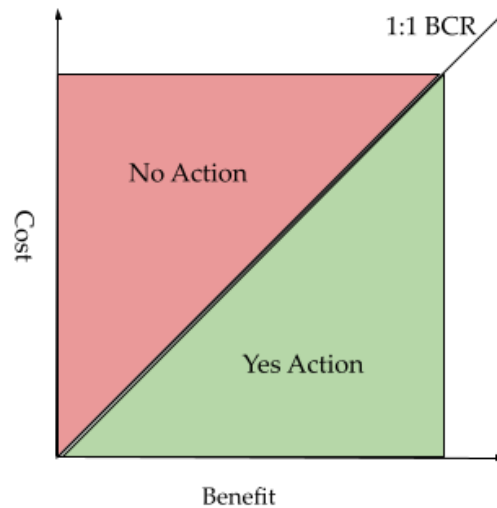


Figure 5: Benefit Cost Ratio and Action Decisions

Source: ECONorthwest

B5.3.2 Fiscal Costs

The most salient costs relevant to seismic school retrofits are fiscal, and these fiscal costs of replacement, retrofitting, or no action are most often calculated using labor and capital inputs. However, these costs can also be organized into direct and indirect costs, and include some not so easily monetized impacts.

In a building replacement scenario, direct costs are made up of the labor, equipment and materials, demolition, and construction costs. There are also indirect costs for the downtime while the school is closed and rebuilt, including costs for childcare, virtual education, and potentially lost wages if a parent needed to reduce working hours for childcare. These costs could be estimated using hourly wage information and childcare cost data. Several studies have analyzed this cost related to unexpected school closures due to COVID-19, and found that there is an effect both on wages and on future earnings for students.⁹

In a building retrofit scenario, labor, equipment, and materials make up the core of the direct fiscal costs which the state will be responsible for. Depending on the extent of retrofitting needed, the size and age of the building, and the availability of contractors, these costs will vary. Expected building seismic upgrade costs can be readily determined by engineering studies. For this study, only buildings receiving concept upgrade reports were assessed for estimated seismic upgrade costs though. For these schools, the average estimated seismic upgrade costs for the

⁹ Lempel, Howard, Joshua M. Epstein, and Ross A. Hammond. "Economic cost and health care workforce effects of school closures in the US." *PLoS currents* 1 (2009).

Psacharopoulos, George, Victoria Collis, Harry A. Patrinos, and Emiliana Vegas. "Lost wages: The COVID-19 cost of school closures." *Available at SSRN 3682160* (2020).

Phase 2 concept upgrade is \$168 per square foot including both construction costs and soft costs. When the -20% to +50% variance is considered, it is expected the average seismic upgrade cost will range between \$135-\$252 per square foot. These costs can easily be monetized in a BCA by multiplying by the building's square footage. Indirect costs of retrofitting include the cost of potential school closures or decreased access to parts of school buildings during construction. These can be qualitatively described in a BCA.

In a no action scenario in which seismic damage does occur, damage repair costs will be direct costs, and there will be indirect costs caused by closing the school for repair. Downtime between damage and the school reopening will result in additional costs. Some estimates show that damage repair costs are significantly higher per square foot than retrofitting costs, with a replacement cost of \$375-\$550 per ft²¹⁰.

Some factors that may affect the costs in either scenario include the current building value and remaining useful life, and what other renovations may already be planned for the building. Old school buildings reaching the end of their useful lives may be less expensive to demolish and rebuild than to retrofit to a life safety level, and bundling retrofitting with other renovations may drive down the marginal price of retrofitting. Building value is also a key driver of the costs in any scenario, and so it is critical to select the correct measure of value. Considering that the costs in these scenarios are mainly derived from replacement and repair, building value should be characterized as the total replacement value of the building. This is often referred to as Plant Replacement Value or Estimated Replacement Value. Other measures of building value, such as assessed value, only capture the market value of a building, and do not capture the entire value of the existence of the building.

B5.3.3 Public Benefits

There are multiple public benefits to retrofitting or replacing school buildings at a safe level, which can be monetized using a variety of economic methods, allowing them to be compared to the costs.

Public safety is the key benefit of retrofitting to a safe level, as that would prevent injury and loss of life. As a public good, public safety is measured as expected damage from the hazard, where lower expected damage is equal to higher public safety. The value of that lower level of expected damage is the public benefit of increased safety. Using information on the cost of injuries and the burden on the healthcare system, the value of avoided injuries can be monetized. The avoided use of emergency and health systems also has a public benefit as those resources would be available to serve others. Measuring the economic value of a life saved through prevented seismic damage is usually done using an established method that implements the Value of a Statistical Life. Economists have estimated the Value of a Statistical Life by measuring the willingness to pay for reductions in small risks of premature death¹¹. This allows a monetary value to be attached to the number of lives that could be saved through avoided earthquake related deaths. For example, the U.S. Department of Transportation uses \$10,900,000 (\$2019)

¹⁰ Personal Correspondence, Dennis Teschlog.

¹¹ Office of Management and Budget. Circular A-4. Retrieved from: https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/

for a fatal injury in its formal BCA guidance¹². Lives saved by retrofitting could amount to a significant public benefit.

Retrofitting or replacing school buildings to a safe level also creates public benefits related to community resilience to natural disasters. The marginal decrease in downtime compared to closing a school for extensive repairs or a rebuild means that the community is able to bounce back faster. There are also cost savings from this shorter downtime for childcare costs. A secure school building could also provide benefits during other natural disasters as an emergency hub. Many communities are willing to pay for emergency shelter construction, but a safe school may provide that value and avoid the need for new infrastructure.

School retrofits also provide an opportunity to conduct other infrastructure updates that may be needed, such as electrical, plumbing, or technology upgrades. These create greater marginal benefits for the school as there may be cost savings from undertaking multiple infrastructure projects at once rather than piecewise.

The local neighborhoods that have these upgraded schools may also receive some public benefit through property value increases from the increase in school quality and safety. In turn this may result in increases in property tax revenue.

B5.3.4 Benefits and Costs Over Time

Economics uses discounting on benefits and costs over time to translate future impacts to present terms. This is particularly relevant when considering school retrofits as it captures the impact of receiving benefits in the uncertain long term and paying costs certainly in the short term. Looking at these impacts over time will help to determine what buildings should be retrofitted at what point in time. This is useful considering that some costs such as repair costs may grow over time as buildings become less resilient to a seismic event over time. Additionally, some benefits may grow over time, for example, a growing population indicates that more people would receive the public benefit of safety over time. The temporal component of BCA can also help to determine the annualized cost of larger projects.

Of particular importance is the selection of an appropriate discount rate for comparing benefits and costs across time. Discounting allows a decision maker to compare costs and benefits over time in equal terms, and is frequently used in economics for both private and public goods.

Generally speaking, there are two basic frameworks for discount rates, the finance-equivalent discount rate and the social-welfare-equivalent discount rate. The finance-equivalent discount rate is derived from the expected rate of return on investment for capital investments, and is representative of forgone returns on resources spent in the present rather than in the future. In practice, 7% is usually used as this finance-equivalent discount rate, and would be most

¹² U.S. Department of Transportation (2021). Benefit-Cost Analysis Guidance for Discretionary Grant Programs. Retrieved from: <https://www.transportation.gov/sites/dot.gov/files/2021-02/Benefit%20Cost%20Analysis%20Guidance%202021.pdf>

appropriately applied to evaluating the impacts of regulatory policy on capital allocation¹³ (i.e. the costs of seismic upgrades).

However, since seismic upgrades would produce both capital costs and public benefits, the social-welfare-equivalent discount rate should be used for capturing “society’s rate of time preference” for consumption in the present compared to the future. Oftentimes, a 3% discount rate is used to account for intergenerational and long time horizon decisions¹⁴.

Health and safety benefits received special consideration. OMB guidance also indicates that when health and safety considerations are considered, the same discount rate should be used for any comparison benefits and costs. Any BCA should carefully consider the selection of a discount rate, and may want to calculate estimates for both discount rates in order to capture the full range of outcomes.

To illustrate the impact of the discount rate, the figure below shows the present value of a future impact over a fifty year time frame under both the three and seven percent discount rate. This demonstrates the importance of sensitivity analysis and using the appropriate discount rate for translating future benefits and costs into present value.

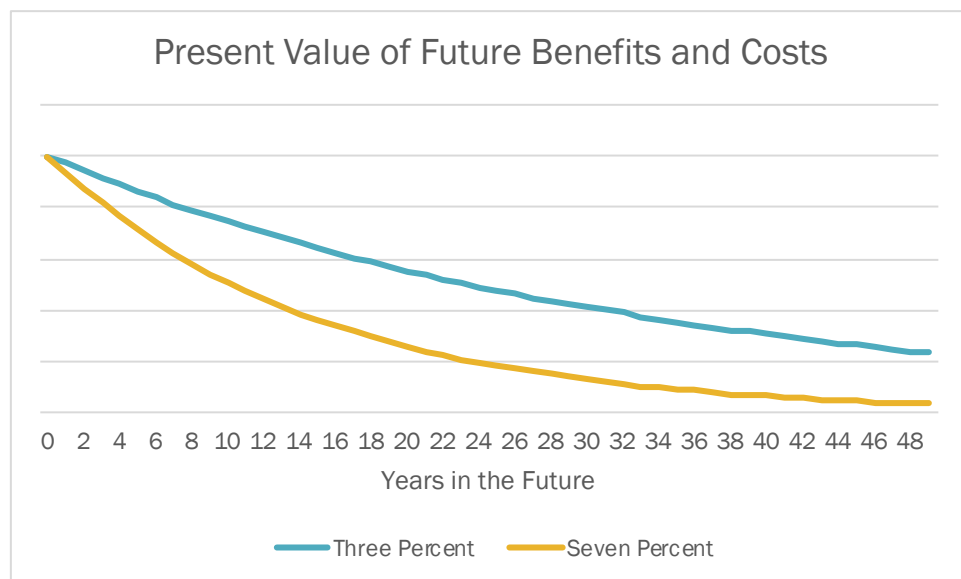


Figure 6: Discounting Future Impacts to Present Value

Source: ECONorthwest

B5.3.5 Evaluating Risk and Uncertainty

Uncertain seismic risk is accounted for in economic analysis using the discount rate and uncertainty analysis which tests the robustness of a decision under a variety of probabilistic

¹³ Office of Management and Budget. Circular A-4. Retrieved from: https://obamawhitehouse.archives.gov/omb/circulars_a004_a-4/

¹⁴ Ibid.

outcomes. In dealing with low-probability, high-consequence, decision-makers show an aversion to both the ambiguity and the uncertain time horizon¹⁵, which can make decisions difficult. Usually individuals demonstrate risk adverse behavior, but the low probability of a seismic event can cause individuals to take on more risk than an Expected Utility Model would predict. This is because assessing risk of low probability events is difficult, as a 2% probability and 0.001% probability both may be perceived as ‘low’. However, the amount of risk that should be taken on, as determined by the expected value of an action, can be vastly different between these two scenarios. For example, if the costs of an event are \$1000 and the probability of that event occurring is ‘low’, the ‘expected value’ (the probability multiplied by the cost) of the event is only \$1 under 0.001% probability, but is twenty times larger at \$20 under a 2% probability of occurrence. Policymakers should be cautious of low probability, high consequence events, as the expected impacts may be more likely than they perceive. In a BCA scenario, a variety of levels of seismic risk could be tested to determine if the benefits are always greater than the costs. This is also used to assess the robustness of BCA results.

B5.3.6 Decision Making Using Benefit Cost Analysis

To illustrate the ways in which BCA should be used, as well as highlight some of the factors which can significantly influence the net impact of an alternative, this section describes several case examples. In these scenarios, the potential differences of one element are examined to show how that may drive a decision one way or the other. In general, the case will identify all relevant impacts that should be captured in a BCA, and highlight the impact that clarifies the decision that maximizes net benefits.

Retrofit or Replace: Building Age and Remaining Useful Life

- Holding cost per square foot and seismic risk constant, differences in remaining and potential added building life can help to determine when to retrofit and when to replace.
 - **Factors to measure and compare:** remaining useful life, added useful life of retrofit, new replacement building lifespan
 - **Example: Older school**
 - Retrofitting an older school may not add to its remaining useful life and replacement may still be necessary. The net benefits of a new safe building are greater than the net benefits of a retrofitted building with only a few years left.
 - Recommendation: Replacement is cost effective.

Wide Distribution of Funds or Focused Spending: Degree of Retrofit

- Holding cost per square foot and remaining useful life constant, differences in the degree of retrofit required can influence when an amount of funding should go to one school or be distributed among many schools.
 - **Factors to measure and compare:** potential damage to building, potential loss of life and injury
 - **Example: Many small retrofits**

¹⁵ Chesson, H.W., Viscusi, W.K. Commonalities in Time and Ambiguity Aversion for Long-Term Risks*. *Theory and Decision* **54**, 57–71 (2003). <https://doi.org/10.1023/A:1025095318208>

- When many schools are already at a level of safety close to life safety and would only require small seismic upgrades the net benefits of updating many schools to a safe level are greater than the net benefits of upgrading only one very expensive school.
- Recommendation: Wide distribution of funds maximizes benefits.

Urban or Rural Spending: Public Benefits

- Holding cost per square foot, seismic risk, and degree of retrofit constant, differences in population size and availability of substitutes can influence the level of public benefits in either an urban or rural setting.
 - **Factors to measure and compare:** population, income level, school building substitutes, downtime costs
 - **Example: Isolated rural school**
 - A school serving fewer students may provide fewer public benefits than one serving a larger population. However, a rural community may have a higher value for their school, and higher downtime costs if there are no nearby substitutes.
 - Recommendation: Rural spending generates more public benefits.

Spend Now or Later: Seismic Risk

- Holding cost per square foot, degree of retrofit, and population constant, seismic risk may drive spending decisions.
 - **Factors to measure and compare:** level of seismic risk
 - **Example: High risk school**
 - High probability of damage from a seismic event means the public benefits of protecting life safety through retrofits will be greater. A threshold level of risk may help to determine which schools should be prioritized for upgrades.
 - Recommendation: Spend now on buildings with higher levels of seismic risk.

B5.3.7 Formal Benefit Cost Analysis Framework

A formal BCA for a given school building can be conducted using a series of equations that incorporate expected probabilities of earthquake scenarios and resulting outcomes. The end result can be either an expected value of a “Benefit Cost Ratio,” or a distribution of values that takes into account the range of earthquake probabilities. Below is an example of how this framework might be applied, using a simplified description of benefits and costs. Any project with a benefit cost ratio greater than one is considered a good investment.

$$\text{Benefit Cost Ratio} = \frac{E[B]}{\text{Cost}}$$

Where:

- *Cost* is the cost of retrofitting a given school building, and
- *E[B]* are the expected present value monetary benefits of retrofitting a school, which is further decomposed as follows.

$$E[B] = \sum_{t=0}^t (Livessaved_t + SchoolClosures_t + RepairCosts_t)e^{rt} + PropertyValue$$

Where:

- t is the time period in which benefits or costs occur
- r is the discount rate

Each of the subcomponents are broken down as follows:

$$Livessaved_t = \sum_{i=1}^i \alpha_i (n * ((PD_i * VSL) + ((1 - PD_i) * PI_i * InjuryCost)))$$

Where:

- α_i is the annual probability of exceedance for a given earthquake indexed by i ,
- n is the average number of individuals in the building at any point in time in a year,
- PD_i is the difference between the fatality rate for an existing building and a retrofitted building for a given earthquake, i ,
- VSL is the Value of a Statistical Life,¹⁶
- PI_i is the difference between the injury rate for an existing building and a retrofitted building for a given earthquake, i , and
- $InjuryCost$ is the average cost per injury from seismic event.

This means over a variety of earthquake scenarios i , and their associated seismic damage risk level α , the value of lives saved and injuries avoided by completing retrofits is the product of the number of children n , the probability of death in each scenario PD_i and the cost of death using that Value of a Statistical Life (VSL), plus the associated probability of injury PI_i per child multiplied by the cost per injury.

$$SchoolClosures_t = \sum_{i=1}^i \alpha_i (n * DC_i (EV + CC))$$

Where:

- DC_i is the difference between the number of days a school is closed for an existing building and a retrofitted building for a given earthquake, i ,
- EV is the lost value of public education value per day of schooling, and
- CC are household childcare costs per day, including lost wages.

This captures the value of avoiding longer and unanticipated school closures over a variety of earthquake scenarios i , and their associated seismic damage risk level α , by multiplying the cost of lost schooling days, lost wages, and of alternative childcare, by the number of days the school will avoid closing for, and summing over all students in the school.

¹⁶ <https://www.epa.gov/environmental-economics/mortality-risk-valuation>

$$RepairCosts_t = \sum_{i=1}^i \alpha_i (ReducedRepairCosts_i)$$

Where:

- RRC_i are the reduced repair costs and reduced building contents damage for a retrofitted building for a given earthquake, i .

Repair costs avoided by retrofitting, are the sum of all reduced repair and clean up costs over a variety of earthquake scenarios i , and their associated seismic damage risk level α .

$$PropertyValue = \beta * \sum PropertyValues$$

Where:

- β is the increase in residential property values from school facility improvements, including retrofitted buildings, and
- $PropertyValues$ are the residential property values in the school district.

This final benefit category captures the marginal benefit β to property owners of an improvement in school quality through retrofitting. This is summed for all properties in the school district, and accrues at the time of retrofit, and thus is not time-determinant.

B5.3.8 Hypothetical Case Study Applying Benefit Cost Analysis

To demonstrate how BCA can inform funding decisions, the above BCA framework is applied to a hypothetical school. The elementary school main building is a two-story concrete structure with brick veneer. The 1948 building is constructed on level ground and is located in western Washington. The building is rectangular in plan, 212 feet by 66 feet, with a maximum roof height of around 42 feet. Building construction consists of concrete walls with brick veneer. The roof system is a flexible diaphragm composed of wood trusses. The floor system is a flexible diaphragm composed of wood joists. The building shares the site with a gymnasium building and two covered play sheds. The school serves an area of 1,000 single family homes with an average property value of \$150,000. It is also assumed that the building is occupied 25% of the time, to account for school days and occasional weekend use throughout the year.

Table 1: Hypothetical School Information

Location:	Western Washington
Enrollment:	176 Students
Staff Size:	10 Teachers and administrators
School Type:	Elementary School
Number of Stories:	2
Year Built:	1948
Square Footage:	25,200
Construction Type:	Nonductile Concrete Shear Walls

Table 2: Seismic Information

ASCE 41 Level of Seismicity:	High	
Soil Site Class:	C	
V_{S30}:	455	m/s
S_S (BSE-2N):	1.084	g
S₁ (BSE-2N):	0.42	g
S_S (BSE-2E):	0.779	g
S₁ (BSE-2E):	0.305	g

Table 3: Seismic Upgrade Information

Estimated Seismic Upgrade Construction Cost per Square Foot:	221	Dollars per Square Foot
Existing Building Replacement Value:	375-425	Dollars per Square Foot
Estimated Seismic Upgrade Cost with Full-Building Modernization	88	Dollars per Square Foot

If seismic upgrades were to be combined with other building modernization tasks, the cost would be reduced by up to 60% due to the reduction in demolition and repair costs. In this hypothetical BCA, both a scenario with combined building modernization, and without are considered.

Earthquake performance information for the school is listed in Table 4 below. Values for expected building damage include the probability of needing to demolish the building following the earthquake under each scenario.

Table 4: Earthquake Performance Information

Probability of Exceedance (a.k.a. "scenario")	Annual Prob. without Exceeding Next Level	Expected Bldg Damage (Existing Bldg) ^{1,5}	Expected Bldg Damage (Retrofit Bldg) ^{1,5}	Fatality Rate (Existing Bldg) ²	Fatality Rate (Retrofit Bldg) ²	Injury Rate (Existing Bldg) ³	Injury Rate (Retrofit Bldg) ³	Expected Net Bldg Contents Damage ⁴
90% in 50 Years	2.22%	8.7%	7.3%	0.06%	0.00%	0.54%	0.00%	0.0%
50% in 30 Years	0.94%	14.3%	7.3%	0.28%	0.00%	2.56%	0.00%	0.0%
50% in 50 Years	0.46%	23.1%	7.5%	0.66%	0.00%	5.99%	0.02%	2.1%
50% in 75 Years	0.23%	33.6%	7.8%	1.11%	0.00%	10.10%	0.08%	5.0%
50% in 100 Years	0.25%	41.4%	8.2%	1.53%	0.00%	13.80%	0.08%	7.5%
20% in 50 Years	0.22%	57.4%	9.4%	2.25%	0.00%	20.30%	0.19%	12.9%
Design Earthquake per ASCE 7	0.02% ⁶	82.4%	12.2%	3.53%	0.00%	32.00%	0.51%	48.5%
10% in 50 Years	0.11%	84.6%	12.9%	3.67%	0.00%	33.20%	0.55%	49.8%
5% in 50 Years	0.01%	100%	17.6%	5.04%	0.00%	45.60%	0.71%	83.8%
Risk-Targeted Maximum	0.05% ⁶	100%	18.7%	5.18%	0.01%	46.90%	0.82%	83.3%

Considered Earthquake per ASCE 7								
2% in 50 Years	0.04%	100%	27.6%	6.59%	0.02%	59.30%	1.28%	76.7%

Notes:

1. Expected building damage is in percent of the building's replacement value.
2. Fatality rate is the likelihood of fatality of a person randomly situated in the building.
3. Injury rate is the likelihood of injury of a person randomly situated in the building.
4. Includes possibility of building being red-tagged per ATC-20 following an earthquake where contents removal is not permitted.
5. Building damage values include the possibility of post-earthquake demolition even when building is not 100% damaged. Building owners often prefer to demolish severely damaged buildings rather than repair them. There are many reasons for this but high repair costs and public perception about building safety are among the reasons why demolition may be preferable.
6. Probabilities are based on comparing the mapped earthquake accelerations for these events to the probabilistic seismic hazard at the site and back-calculating the return period and annual earthquake probability.

Additionally, the number of days the school is expected to be closed following each earthquake scenario is assumed to be the product of the expected building damage and 365. The current Value of Statistical Life used by federal agencies to value mortality reduction is \$9.97 million.¹⁷ The average injury cost is \$19,539 and is determined using the average bodily injury claim in auto accidents.¹⁸ The average value of a day of schooling and childcare, \$37 and \$33, respectively, is drawn from U.S. Census estimates allocated across all 365 days in a year.¹⁹ Community property value gains are based on empirical estimates.²⁰

Table 5: Annual Benefit Component Calculation Per Scenario

Probability of Exceedance (a.k.a. "scenario")	Return Period (years)	Lives Saved/Injuries Prevented	School Closures	Repair Costs
90% in 50 Years	22	\$6,284	\$1,398	\$3,133
50% in 30 Years	43	\$12,420	\$2,948	\$6,609
50% in 50 Years	72	\$14,437	\$3,248	\$8,260
50% in 75 Years	108	\$12,121	\$2,686	\$7,187
50% in 100 Years	144	\$17,896	\$3,703	\$10,175
20% in 50 Years	224	\$23,351	\$4,753	\$13,516
Design Earthquake per ASCE 7	442	\$2,614	\$496	\$1,881
10% in 50 Years	475	\$18,667	\$3,481	\$13,222
5% in 50 Years	975	\$1,782	\$278	\$1,258
Risk-Targeted Maximum Considered Earthquake per ASCE 7	1052	\$13,329	\$1,998	\$9,068

¹⁷ <https://www.epa.gov/environmental-economics/mortality-risk-valuation#whatvalue>

¹⁸ <https://www.iii.org/fact-statistic/facts-statistics-auto-insurance>

¹⁹ <https://www.census.gov/newsroom/blogs/research-matters/2015/12/census-bureau-statistics-allow-for-deeper-dive-into-rising-costs-of-child-care.html>

²⁰ https://www.nber.org/system/files/working_papers/w9054/w9054.pdf

2% in 50 Years	2475	\$12,509	\$1,315	\$6,072
Annual Expected Value		\$135,410	\$26,303	\$80,381

Calculated across an expected 50-year lifetime at both a 7% and 3% discount rate generates expected benefits of seismic retrofit that range between \$5.08 and \$7.97 million, respectively. The cost of the seismic retrofit is estimated at \$5.57 million (\$221 per square foot times 25,200 square feet). Without the added building modernization effect, the benefit cost ratio ranges from 0.9 to 1.4, depending on the discount rate.²¹ This means that if the upgrades are being done on their own, economics generally supports seismic upgrades depending on the discount rate. A benefit cost ratio that exceeds 1.0 indicates that seismic retrofit makes sense economically. However, when combined with a full-building modernization where architectural, mechanical, electrical and plumbing costs are allocated separately from the seismic retrofit costs, the cost of seismic retrofit is estimated at \$2.23 million. In this scenario the benefits significantly exceed the costs of retrofit, and the benefit cost ratio ranges between 2.3 and 3.5. This cost sharing results in a benefit cost ratio that indicates that seismic retrofits should be undertaken immediately when combined with other building modernization upgrades. Unsurprisingly, depending on the discount rate, 39% - 45% of the benefits accrue from lives saved.

B5.4 Funding and Decision Making

Given that funding for seismic upgrades could be provided in multiple ways, several decision making frameworks are relevant. Depending on the type of funding stream – specifically steady, discrete, or discretionary - different types of projects may be targeted to optimize the net benefits of that type of funding.

In the case of a steady flow of funding, a programmatic approach that prioritizes low hanging fruit and low impact projects that provide incremental benefits at a relatively low cost is often most impactful. This framework assumes the funding is insufficient for all needed upgrades, and prioritizes maximizing both the quantity and quality of completed upgrades. This casts the widest net and improves net benefits as well as distributional impacts.

Figure 7: Steady Funding Prioritization:



However, if the need for seismic upgrades dictates funding, meaning funding is provided for discrete needs, it may produce the most net benefits to start with high impact/high-cost projects while political enthusiasm is high, and plan for low-cost projects later. This is because prioritizing high cost/high impact projects in this scenario provides the largest benefits as quickly as possible.

²¹ Results are interpreted across the range of appropriate discount rates to help decisionmakers financial and public benefit considerations. Since nearly half of the benefits are public benefits accruing from lives saved, it is reasonable to base seismic decisions on the results of the 3% discount rate, which produces a benefit cost ratio of 1.4.

Figure 8: Discrete Needs Funding Prioritization:



Finally, if the funding stream is uncertain or discretionary and variable from year to year, net benefits are maximized by prioritizing low-cost projects which yield high net benefits, often characterized as the ‘low-hanging fruit’, followed by prioritization of other high impact projects. This is because it is important to take advantage of funding while political enthusiasm and support is high, and save smaller, lower cost projects for when less funding may be provided.

Figure 9: Discretionary Funding Prioritization:



B5.4.1 OSPI Current Funding Decisions

As mentioned in section 6.1 OSPI has obtained additional funding to continue to conduct seismic safety retrofits. At the moment, schools are receiving funds based on “risk level, building use, district financial capacity, and anticipated building life.”²² Additional guidance from the Legislature has specified that OSPI “shall prioritize buildings with the most significant building deficiencies and the greatest seismic risks ... beginning with facilities classified as very high risk.”²³ These principles are a guiding framework for spending decisions, and are easily incorporated into a formal economic assessment of project benefits and costs. Since the biennial funding amount is uncertain year to year, it maximizes benefits to fund larger higher impact projects first, and wait to implement lower cost projects that can be met with potentially less funding later. As a general principle though, if any retrofit project has a benefit cost ratio greater than one, it should be executed as soon as possible.

B5.5 Other Considerations

B5.5.1 Earthquake Insurance

Earthquake insurance is not required in Washington State despite it having the second highest seismic risk in the nation. High risk of seismic damage drives often expensive insurance premiums meant to protect insured entities from the shock of a seismic event. Retrofitting school buildings may lower earthquake insurance costs since the risk of severe damage will decrease in high-risk areas. However, Washington State varies in seismic risk, so earthquake insurance may not be universally needed. In either scenario, these costs are not considered in a benefit cost analysis because insurance reallocates risk across time but does not impact the overall benefits or

²² OSPI 2021-23 Capital Budget Requests One-Pager, pg. 2. Retrieved from: <https://www.k12.wa.us/sites/default/files/public/schfacilities/pubdocs/2021-23-Capital-Budget-Requests-Summary.pdf>

²³ OSPI 350 2021-23 Biennial Capital Budget Request, pg. 44. <https://www.k12.wa.us/sites/default/files/public/schfacilities/pubdocs/OSPI%20CBR%20FINAL.pdf>

costs of a given scenario. Earthquake insurance is useful for jurisdictions that would like to protect themselves from financial insolvency in a worst-case scenario though.

B5.5.2 Earthquakes and Other Natural Disasters (COVID)

Earthquakes are very similar to many other natural disasters in that they are low probability but high consequence events, and like many other hazards, it is almost always preferable to be prepared and establish resilient systems rather than have to repair and rebuild after a natural disaster.

As we have seen in the last year, many people have demonstrated a strong preference for being able to send their children back to school quickly and safely. We've also seen a willingness to pay for protecting life and safety from uncertain hazards. This might be expected to carry over to recovery from other natural disasters. Preparedness avoids long downtimes, and may have a lower per unit cost than repair. Seismic resilience may provide resiliency to other natural disasters such as flooding and landslides as well.

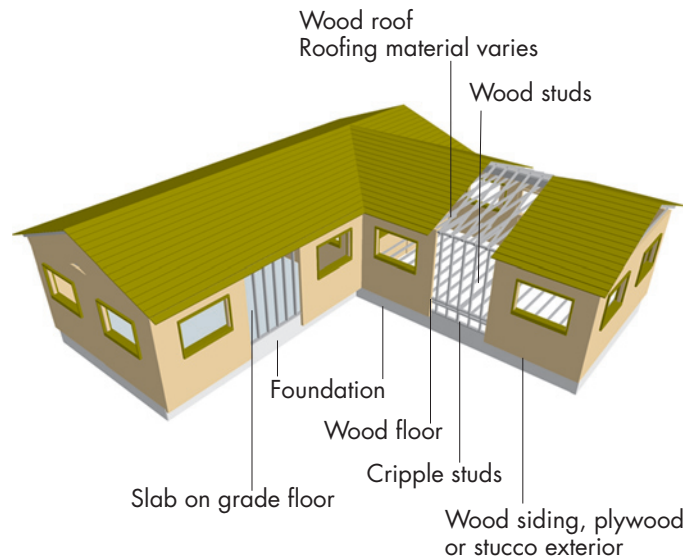
APPENDIX B.6: FEMA REFERENCE DOCUMENTS (BUILDING TYPES, IRREGULARITIES, FEMA E-74 NONSTRUCTURAL SEISMIC BRACING EXCERPTS)

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FEMA BUILDING TYPES AND IRREGULARITIES

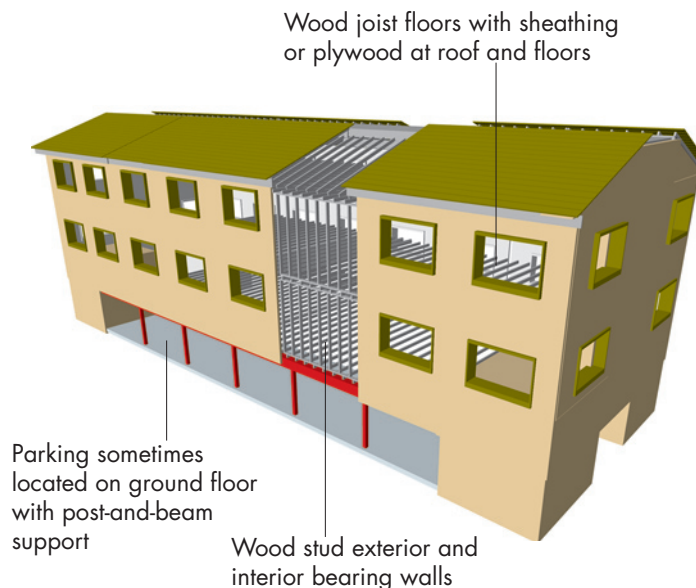
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FEMA Building Type W1 WOOD LIGHT FRAME (small residence)



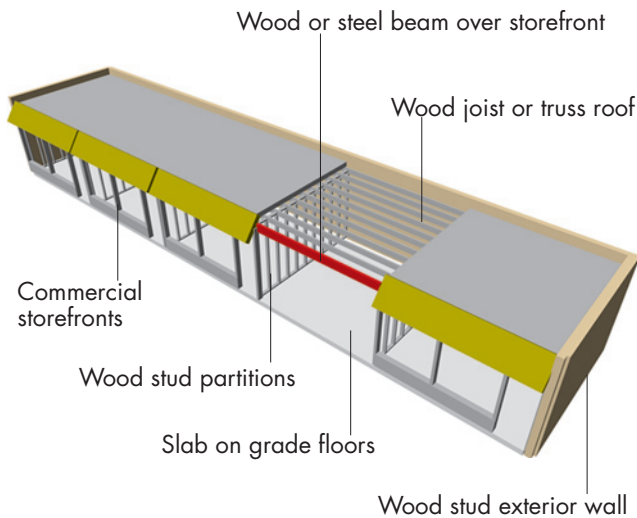
These buildings are generally single-family dwellings of one and two stories. Floor and roof framing consists of wood joists or rafters supported on wood studs spaced no more than 24 inches apart. The first floor may be slab on grade or wood raised above grade with cripple stud walls and post-and-beam supports. Lateral support is provided with shear walls of plywood, stucco, gypsum board, and a variety of other materials. Most often there is no engineering design for lateral forces.

FEMA Building Type W1A WOOD LIGHT FRAME (multi-unit residence)



These buildings are framed with the same systems as W1 buildings but are most often multiple-story large residential-type structures, and, unless very old, are engineered. A common seismic deficiency is the tuck-under parking at the ground story that creates a soft or weak story. This building type is also often built on top of a one story concrete parking structure.

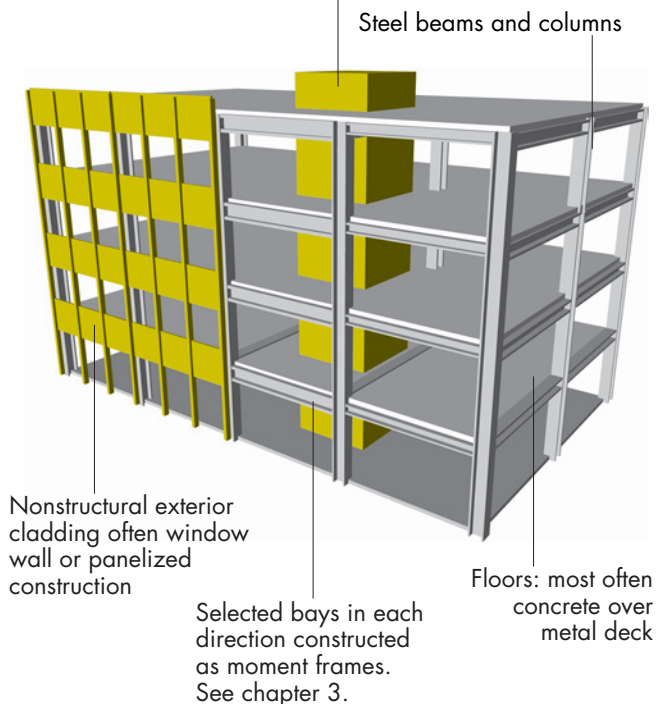
FEMA Building Type W2 WOOD FRAME (commercial and industrial)



These buildings are commonly commercial or smaller industrial buildings and are constructed primarily of wood framing. The floor and roof framing consists of wood joists and wood or steel trusses, glulam or steel beams, and wood posts or steel columns. Lateral forces are resisted by wood diaphragms and exterior stud walls sheathed with plywood, stucco, or wood sheathing, or sometimes rod bracing or a spot steel-braced frame. Large wall openings are common for storefronts or garage openings. This building type is also often used for schools, churches and clubhouses.

FEMA Building Type S1 STEEL MOMENT FRAMES

Vertical shafts of nonstructural materials

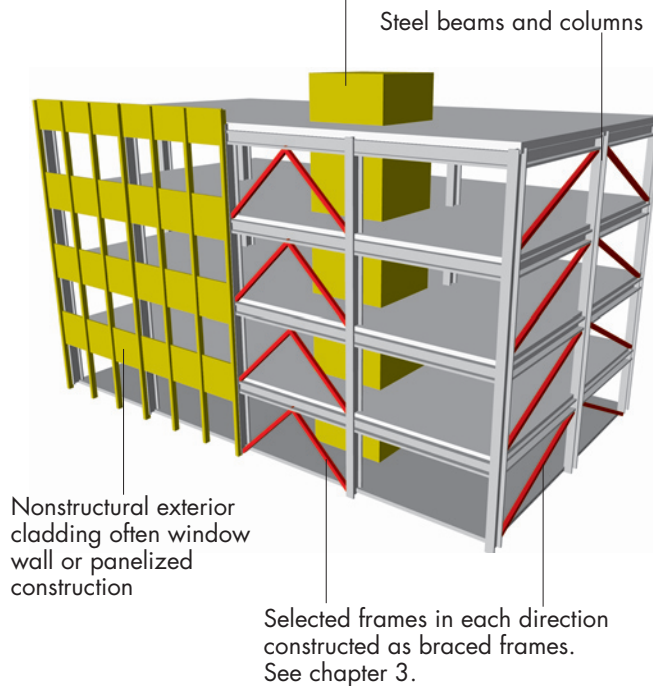


These buildings consist of an essentially complete frame assembly of steel beams and columns. Lateral forces are resisted by moment frames that develop stiffness through rigid connections of the beam and column created by angles, plates and bolts, or by welding. Moment frames may be developed on all framing lines or only in selected bays. It is significant that no structural walls are required. Floors are cast-in-place concrete slabs or metal deck and concrete. This building is used for a wide variety of occupancies such as offices, hospitals, laboratories, and academic and government buildings.

The S1A building type is similar but has floors and roof that act as flexible diaphragms, such as wood or uptopped metal deck. One family of these buildings are older warehouse or industrial buildings, while another more recent use is for small office or commercial buildings in which the fire rating of concrete floors is not needed.

FEMA Building Type S2 STEEL-BRACED FRAMES

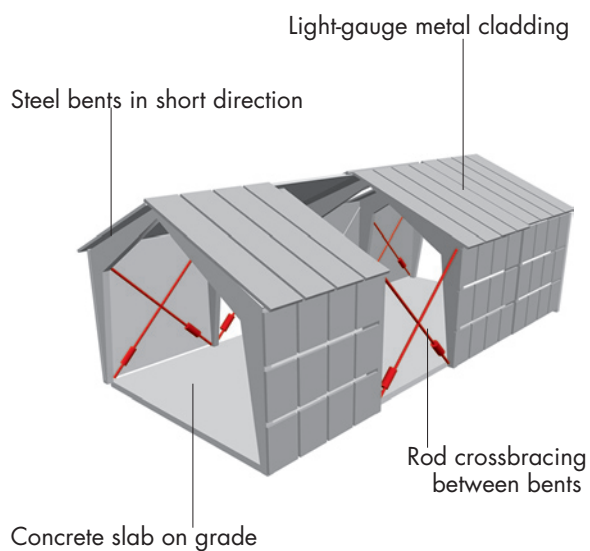
Braced frames often placed within shaft walls



These buildings consist of a frame assembly of steel columns and beams. Lateral forces are resisted by diagonal steel members placed in selected bays. Floors are cast-in-place concrete slabs or metal deck and concrete. These buildings are typically used for buildings similar to steel-moment frames, although are more often low rise.

The S2A building type is similar but has floors and roof that act as flexible diaphragms such as wood, or upturned metal deck. This is a relatively uncommon building type and is used mostly for smaller office or commercial buildings in which the fire rating of concrete floor is not needed.

FEMA Building Type S3 STEEL LIGHT FRAMES

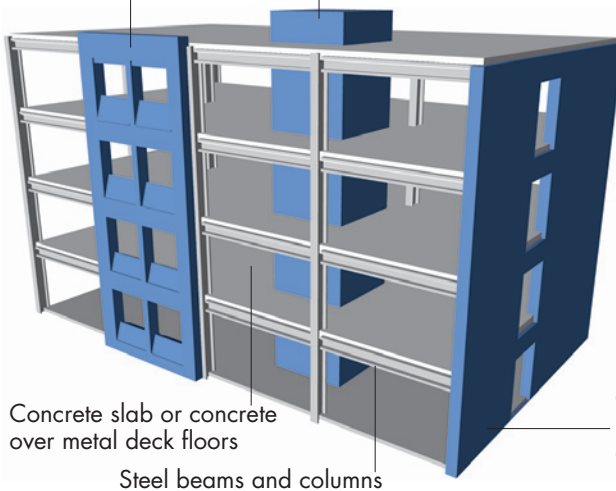


These buildings are one story, pre-engineered and partially prefabricated, and normally consist of transverse steel bents and light purlins. The roof and walls consist of lightweight metal, fiberglass, or cementitious panels. Lateral forces are resisted by the transverse steel bents acting as moment frames, and light rod diagonal bracing in the longitudinal direction. The roof diaphragm is either metal deck or diagonal rod bracing. These buildings are mostly used for industrial or agricultural occupancies.

FEMA Building Type S4 STEEL FRAMES with concrete shearwalls

"Punched" concrete exterior walls are an alternate shear-wall configuration

Vertical shafts often constructed of concrete

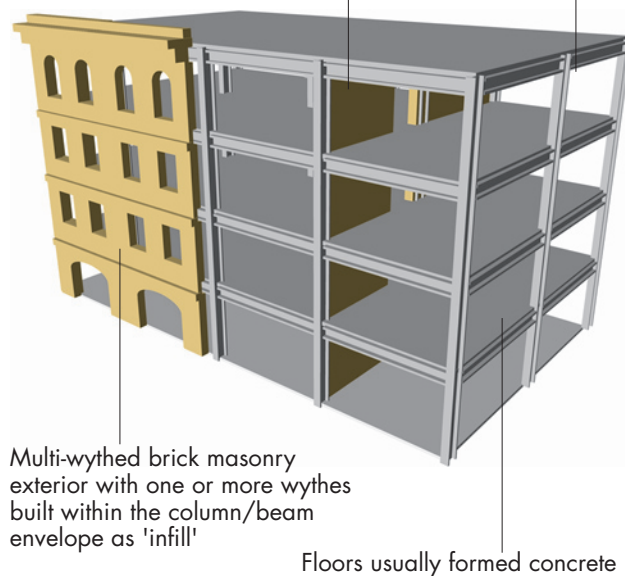


These buildings consist of an essentially complete frame assembly of steel beams and steel columns. The floors are concrete slabs or concrete fill over metal deck. The buildings feature a significant number of concrete walls effectively acting as shear walls, either as vertical transportation cores, isolated in selected bays, or as a perimeter wall system. The steel column-and-beam system may act only to carry gravity loads or may have rigid connections to act as a moment frame. This building type is generally used as an alternate for steel moment or braced frames in similar circumstances. These buildings will usually be mid- or low-rise.

FEMA Building Type S5 STEEL FRAMES with infill masonry walls

Interior partitions or shaft walls often built with clay tile

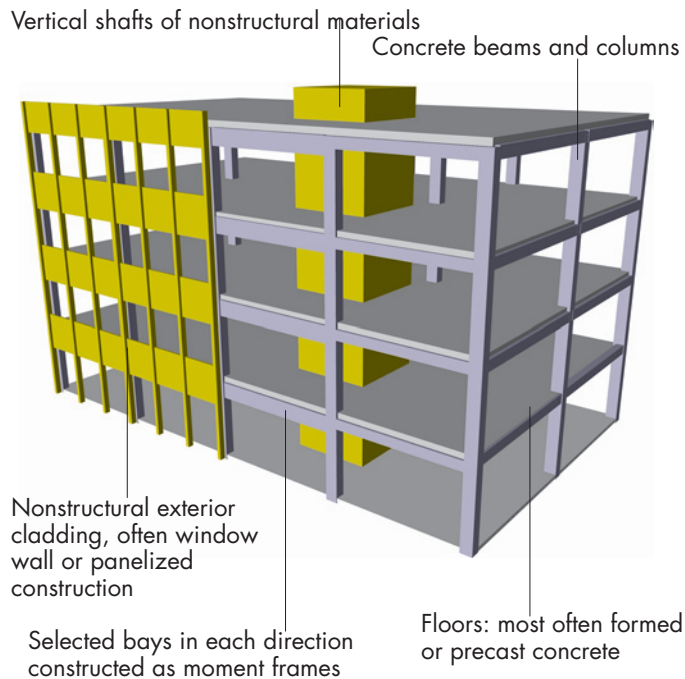
Steel beams and columns



This is normally an older building that consists of an essentially complete frame assembly of steel floor beams or trusses and steel columns. The floor consists of masonry flat arches, concrete slabs or metal deck, and concrete fill. Exterior walls and possibly some interior walls, are constructed of unreinforced solid clay brick, concrete block, or hollow-clay tile masonry infilling the space between columns and beams. Windows and doors may be present in the infill walls, but to act effectively as shear-resisting elements, the infill masonry must be constructed tightly against the columns and beams. Although relatively modern buildings in moderate or low seismic regions are built with unreinforced masonry exterior infill walls, the walls are generally not built tight against the beams and columns and therefore do not provide shear resistance. The buildings intended to fall into this category feature exposed clay brick masonry on the exterior and are common in commercial areas of cities with occupancies of retail stores, small offices, and hotels.

The S5A building type is similar but has floors and roof that act as flexible diaphragms, such as wood or upturned metal deck. These buildings will almost all date to the 1930s and earlier, and were originally warehouses or industrial buildings.

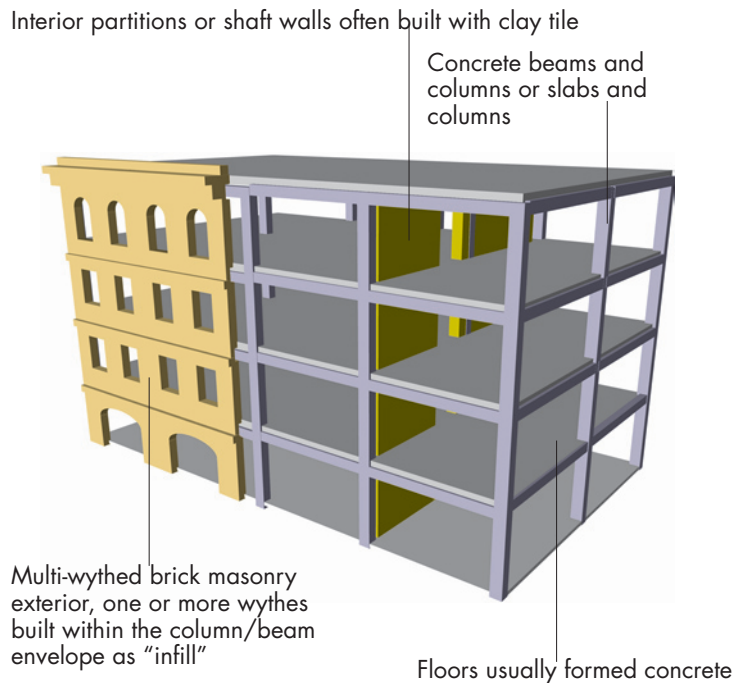
FEMA Building Type C1 CONCRETE MOMENT FRAMES



These buildings consist of concrete framing, either a complete system of beams and columns or columns supporting slabs without gravity beams. Lateral forces are resisted by moment frames that develop stiffness through rigid connections of the column and beams placed in a given bay. Moment frames may be developed on all framing lines or only in selected bays. It is significant that no structural walls are required. Floors are cast-in-place or precast concrete. Buildings with concrete moment frames could be used for most occupancies listed for steel moment frames, but are also used for multistory residential buildings.

The C1A building type is similar but has floors and roof that act as flexible diaphragms, such as wood or uptopped metal deck. This is a relatively unusual building type, but might be found as older warehouse-type buildings or small office occupancies.

FEMA Building Type C3 CONCRETE FRAMES with infill masonry shear walls



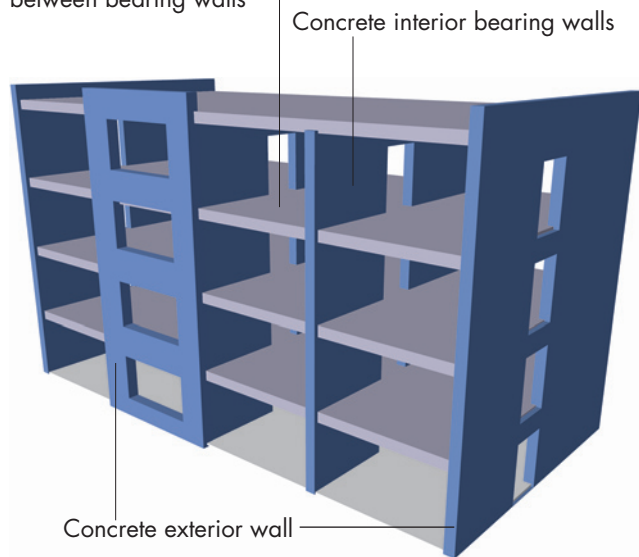
These buildings consist of concrete framing, either a complete system of beams and columns or columns supporting slabs without gravity beams. Exterior walls and possibly some interior walls are constructed of unreinforced solid clay brick, concrete block, or hollow clay tile masonry infilling the space between columns and beams. Windows and doors may be present in the infill walls, but to act effectively as shear-resisting elements, the infill masonry must be constructed tightly against the columns and beams. The building type is similar to S5, but is more often used for industrial and warehouse occupancies.

The C3A building type is similar but has floors and roof that act as flexible diaphragms, such as wood, or uptopped metal deck. This building type not often found except as one-story industrial buildings.

FEMA Building Type C2 CONCRETE SHEAR WALLS

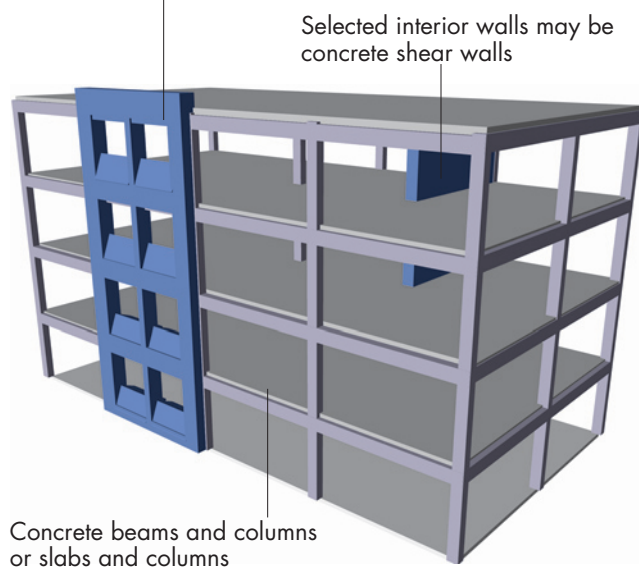
with bearing walls

Precast or formed floors span between bearing walls



with gravity frames

Exterior walls: punched concrete shearwalls or concrete pier-and-spandrel system



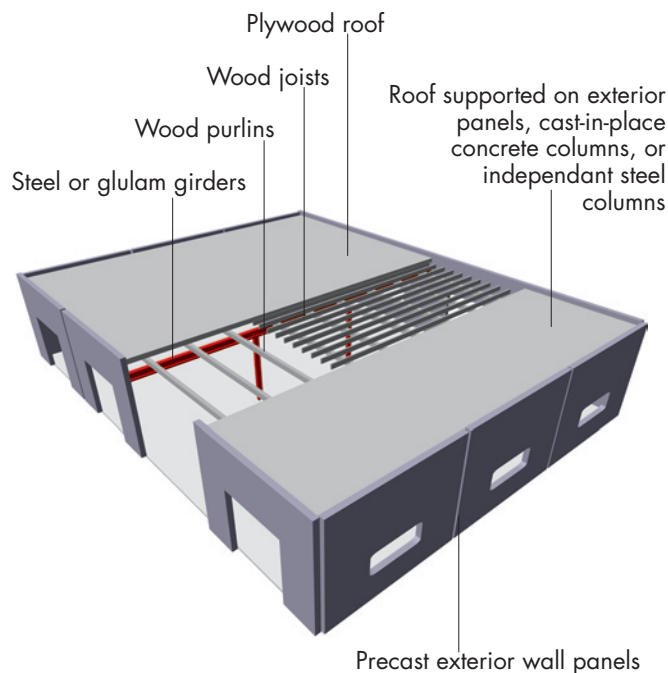
Concrete shear walls are concrete walls in a building design to provide lateral stiffness and strength for lateral loads. There are two main types of shear-wall buildings, those in which the shear walls also carry the gravity loads (with bearing walls), and those in which a column-supported framing system carries the gravity loads (with gravity frame).

In the **bearing wall** type, all walls usually act as both bearing and shear walls. The building type is similar and often used in the same occupancies as type RM2, namely in mid- and low-rise hotels and motels. This building type is also used in residential apartment/condo-type buildings.

In **gravity frame** buildings, shear walls are either strategically placed around the plan, or at the perimeter. Shear-wall systems placed around the entire perimeter must contain the windows, and other perimeter openings are called punched shear walls. These buildings were commonly built in the 1950s and 1960s for a wide variety of most institutional occupancy types.

The C2A building type is similar, but has floors and roof that act as flexible diaphragms such as wood, or uptopped metal deck. C2A buildings are normally bearing-wall buildings. These buildings are similar to building-type RM1 and are used for similar occupancies- such as small office or commercial and sometimes residential.

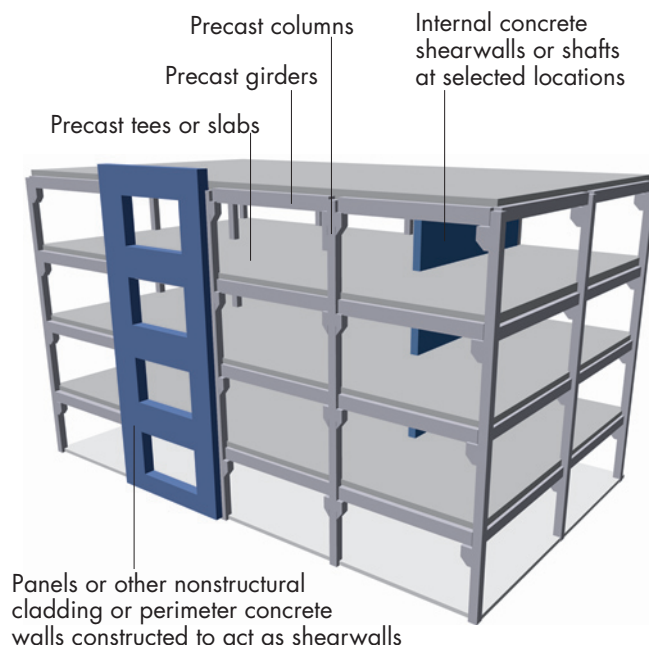
FEMA Building Type PC1 TILT-UP CONCRETE shear walls



These buildings are constructed with perimeter concrete walls precast on the site and tilted up to form the exterior of the buildings, to support all or a portion of the perimeter roof load, and to provide seismic shear resistance. These buildings are commonly one-story with a wood joist and plywood roof or sometimes with a roof of steel joists and metal deck. Two-story tilt-ups usually have a steel-framed second floor with metal deck and concrete and a wood roof. Tilt-up walls that support roof load are very common on the West Coast; due to economical construction cost, they are used for many occupancies, including warehouses, retail stores, and offices. In other parts of the country, these buildings more often have an independent load-carrying system on the inside face of the walls.

The PC1A building is similar but features all floors and/or roof constructed of materials that form a rigid diaphragm, normally concrete. This building type is similar to PC2.

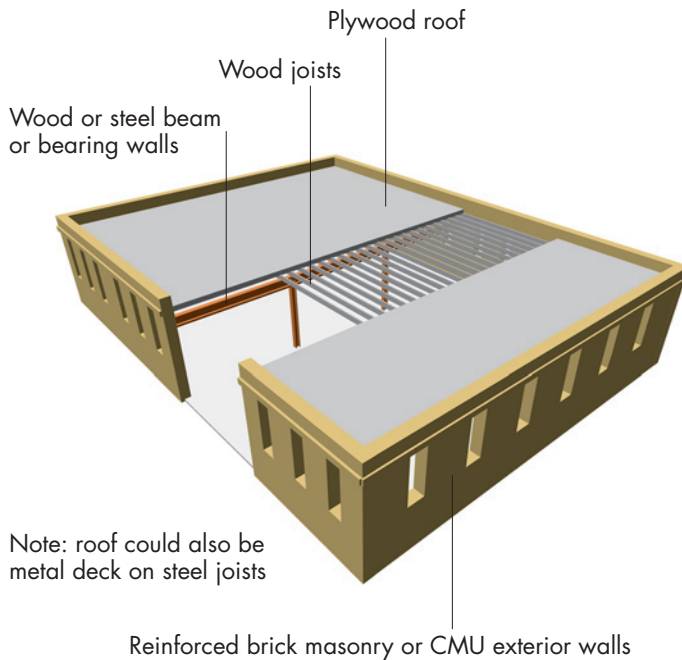
FEMA Building Type PC2 PRECAST CONCRETE FRAMES with shear walls



These buildings consist of concrete columns, girders, beams and/or slabs that are precast off the site and erected to form a complete gravity-load system. Type PC2 has a lateral force-resisting system of concrete shear walls, usually cast-in-place. Many garages have been built with this system. The building type is most common in moderate and low seismic zones and could be used for many different occupancies in those areas.

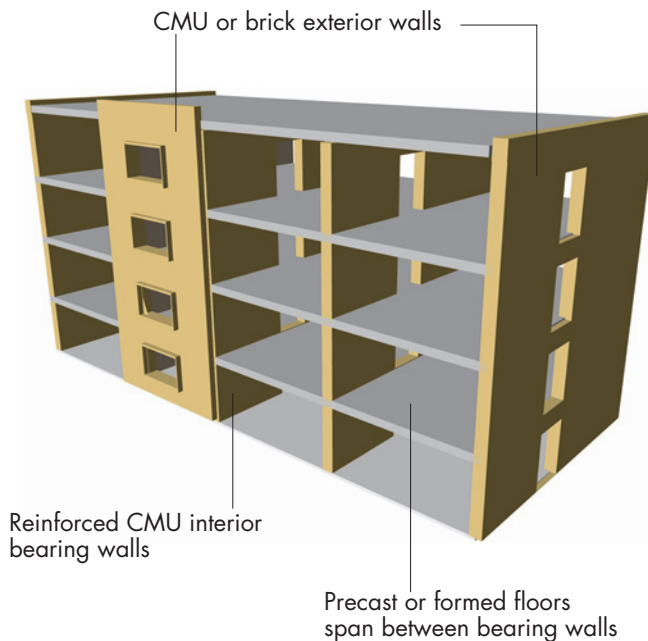
The PC2A building is similar but obtains lateral support from specially connected precast girders and columns that form moment frames. Until recently, precast moment frames have not been allowed in regions of high seismicity, and these buildings will essentially only be found in moderate or low seismic zones.

FEMA Building Type RM1 REINFORCED MASONRY WALLS with flexible diaphragms



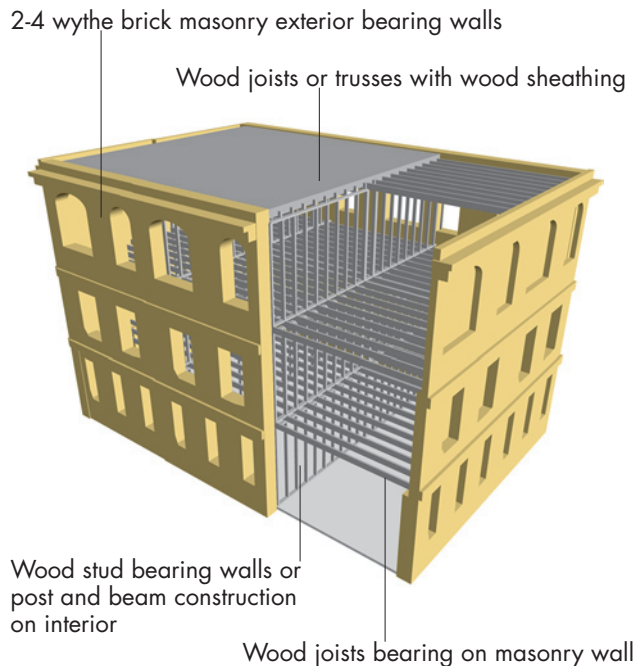
These buildings take a variety of configurations, but they are characterized by reinforced masonry walls (brick cavity wall or CMU) with flexible diaphragms, such as wood or metal deck. The walls are commonly bearing, but the gravity system often also contains post-and-beam construction of wood or steel. Older buildings of this type are generally small and were used for a wide variety of occupancies and are configured to suit. Recently, the building type is commonly used for one-story warehouse-type occupancies similar to tilt-up buildings.

FEMA Building Type RM2 REINFORCED MASONRY WALLS with stiff diaphragms



This building consists of reinforced masonry walls and concrete slab floors that may be either cast-in-place or precast. This building type is often used for hotel and motels and is similar to the concrete bearing-wall type C2.

FEMA Building Type URM UNREINFORCED MASONRY BEARING WALLS



This building consists of unreinforced masonry bearing walls, usually at the perimeter and usually brick masonry. The floors are wood joists and wood sheathing supported on the walls and on interior post-and-beam construction or wood-stud bearing walls. This building type is ubiquitous in the U.S. and was built for a wide variety of uses, from one-story commercial or industrial occupancies, to multistory warehouses, to mid-rise hotels. Unfortunately, it has consistently performed poorly in earthquakes. The most common failure is an outward collapse of the exterior walls, caused by loss of lateral support due to separation of the walls from the floor/roof diaphragm.

The URMA building is similar, but features all floors and/or roof constructed of materials that form a rigid diaphragm, usually concrete slabs or steel joists with flat-arched unreinforced masonry.

moment-frame buildings have received damage to their beam-column connections when subjected to strong shaking. Even in these cases, the damage is not 100% consistent and certainly not 100% predictable. In building types with less vulnerability, the damage has an even higher coefficient of variation. Engineers and policymakers, therefore, have struggled with methods to reliably evaluate existing buildings for their seismic vulnerability.

As discussed in Section 8.2, the initial engineering response was to judge older buildings by their capacity to meet the code for new buildings, but it became quickly apparent that this method was overly conservative, because almost every building older than one or two code-change cycles would not comply—and thus be considered deficient. Even when lower lateral force levels were used, and the presence of archaic material was not, in itself, considered a deficiency, many more buildings were found

Figure 5-5: Horizontal (Plan) Irregularities (based on IBC, Section 1616.5.1).




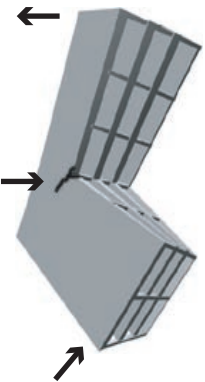
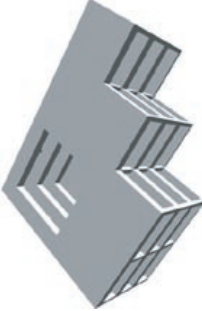
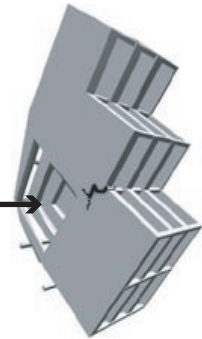



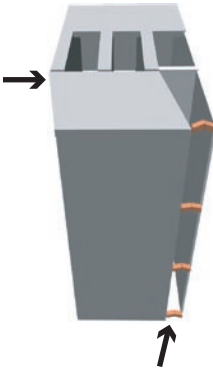


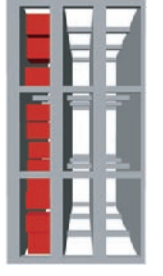
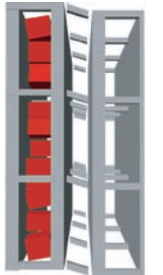

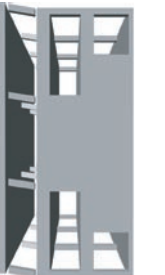

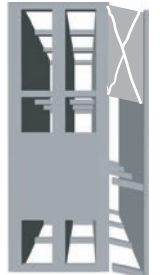


plan conditions	resulting failure patterns	performance	code remedies
		P1 Torsional Irregularity: Unbalanced Resistance	
		Localized damage. Collapse mechanism in extreme instances.	Modal Analysis, +65 foot high in SDC D,E,F. 25% increase to diaphragm connection design forces. Amplified forces to max of X3.
		P2 Re-entrant Corners Local damage to diaphragm and attached elements. Collapse mechanism in extreme instances in large buildings.	25% increase in diaphragm connection design forces.
		P3 Diaphragm Eccentricity and Cutouts Localized structural damage.	25% increase in diaphragm connection design forces.
		P4 Nonparallel Lateral Force-Resisting System Leads to torsion and instability, localised damage.	Combine 100% and 30% of forces in 2 directions, use maximum.
		P5 Out-of-Plane Offsets: Discontinuous Shearwalls Collapse mechanism in extreme circumstances.	Modal Analysis, +65 foot high in SDC D,E,F. 25% increase to diaphragm connection design forces.

Figure 5-6: Vertical Irregularities (based on IBC, Section 1616.5.2).

vertical conditions	resulting failure patterns	performance	code remedies
		V1 Stiffness Irregularity: Soft Story	
		Common collapse mechanism. Death and much damage in Northridge earthquake.	Modal Analysis, +65 feet high in SCD D,E,F. Extreme case not permitted in seismic use groups E and F.
		V2 Weight/Mass Irregularity	
		Collapse mechanism in extreme circumstances.	Modal Analysis, +65 foot high in SCD D,E,F.
		V3 Vertical Geometric Irregularity	
		Localized structural damage.	Modal Analysis, +65 foot high in SCD D,E,F.
		V4 In-Plane Irregularity in Vertical Lateral Force System	
		Localized structural damage.	Model Analysis, +65 foot high is SCD D, E, F. 25% increase to diaphragm connection design force. Supporting members designed for increased forces.
		V5 Capacity Discontinuity: Weak Story	
		Collapse mechanism in extreme circumstances	Modal Analysis, +65 foot high in SCD D,E,F.

B.5 Vertical Irregularity Reference Guide

Table B-4 Vertical Irregularity Reference Guide

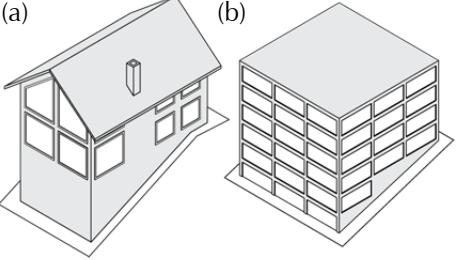
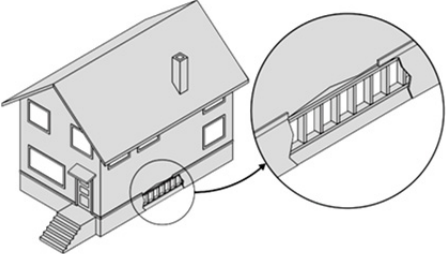
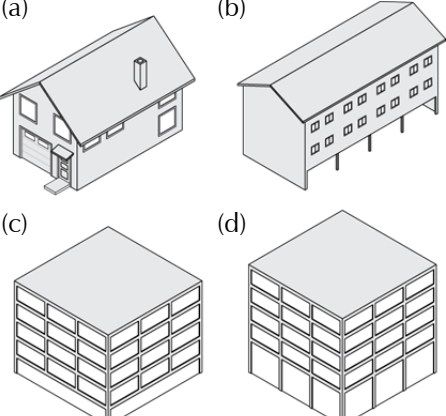
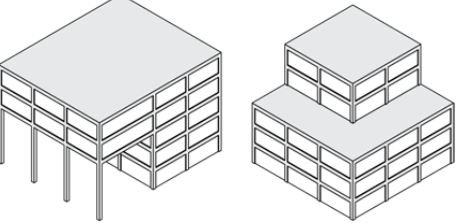
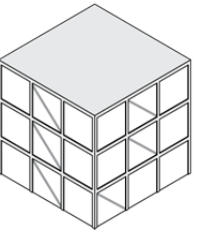
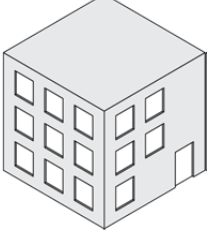
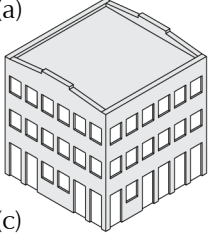
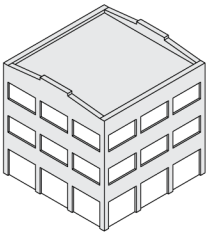
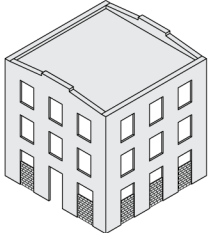
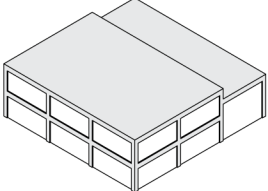
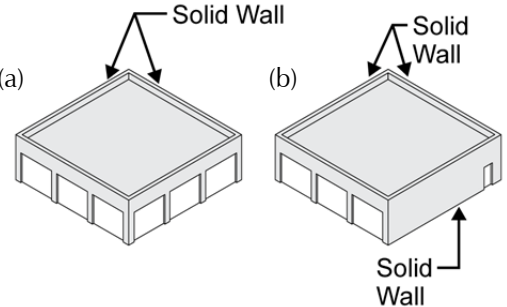

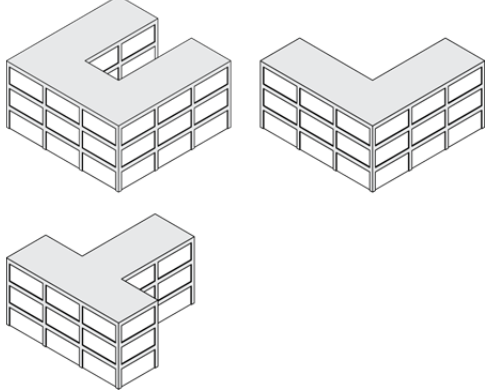
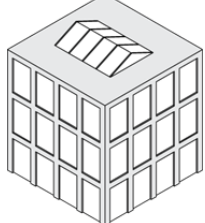
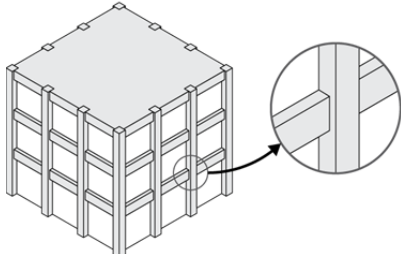
	Vertical Irregularity	Severity	Level 1 Instructions
Sloping Site		Varies	<p>Apply if there is more than a one-story slope from one side of the building to the other. Evaluate as Severe for W1 buildings as shown in Figure (a); evaluate as Moderate for all other building types as shown in Figure (b).</p>
Unbraced Cripple Wall		Moderate	<p>Apply if unbraced cripple walls are observed in the crawlspace of the building. This applies to W1 buildings. If the basement is occupied, consider this condition as a soft story.</p>
Weak and/or Soft Story		Severe	<p>Apply:</p> <p>Figure (a): For a W1 house with occupied space over a garage with limited or short wall lengths on both sides of the garage opening.</p> <p>Figure (b): For a W1A building with an open front at the ground story (such as for parking).</p> <p>Figure (c): When one of the stories has less wall or fewer columns than the others (usually the bottom story).</p> <p>Figure (d): When one of the stories is taller than the others (usually the bottom story).</p>
Out-of-Plane Setback		Severe	<p>Apply if the walls of the building do not stack vertically in plan. This irregularity is most severe when the vertical elements of the lateral system at the upper levels are outboard of those at the lower levels as shown in Figure (a). The condition in Figure (b) also triggers this irregularity. If nonstacking walls are known to be nonstructural, this irregularity does not apply.</p> <p>Apply the setback if greater than or equal to 2 feet.</p>

Table B-4 Vertical Irregularity Reference Guide (continued)

Vertical Irregularity	Severity	Level 1 Instructions
<p>In-plane Setback</p>	<p>(a)  (b) </p>	<p>Moderate</p> <p>Apply if there is an in-plane offset of the lateral system. Usually, this is observable in braced frame (Figure (a)) and shear wall buildings (Figure (b)).</p>
<p>Short Column/Pier</p>	<p>(a)  (b)  (c) </p>	<p>Severe</p> <p>Apply if:</p> <p>Figure (a): Some columns/piers are much shorter than the typical columns/piers in the same line.</p> <p>Figure (b): The columns/piers are narrow compared to the depth of the beams.</p> <p>Figure (c): There are infill walls that shorten the clear height of the column.</p> <p>Note this deficiency is typically seen in older concrete and steel building types.</p>
<p>Split Levels</p>	<p></p>	<p>Moderate</p> <p>Apply if the floors of the building do not align or if there is a step in the roof level.</p>

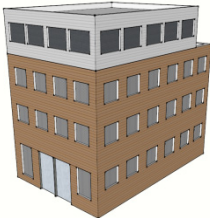
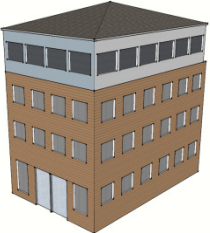
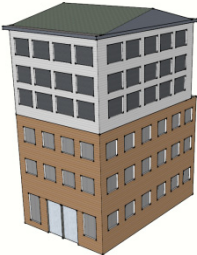

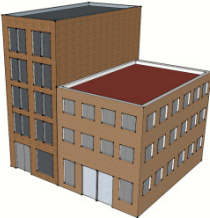
B.6 Plan Irregularity Reference Guide

Table B-5 Plan Irregularity Reference Guide

	Plan Irregularity	Level 1 Instructions
Torsion		<p>Apply if there is good lateral resistance in one direction, but not the other, or if there is eccentric stiffness in plan (as shown in Figures (a) and (b); solid walls on two or three sides with walls with lots of openings on the remaining sides).</p>
Non-Parallel Systems		<p>Apply if the sides of the building do not form 90-degree angles.</p>
Reentrant Corner		<p>Apply if there is a reentrant corner, i.e., the building is L, U, T, or + shaped, with projections of more than 20 feet. Where possible, check to see if there are seismic separations where the wings meet. If so, evaluate for pounding.</p>
Diaphragm Openings		<p>Apply if there is a opening that has a width of over 50% of the width of the diaphragm at any level.</p>
Beams do not align with columns		<p>Apply if the exterior beams do not align with the columns in plan. Typically, this applies to concrete buildings, where the perimeter columns are outboard of the perimeter beams.</p>

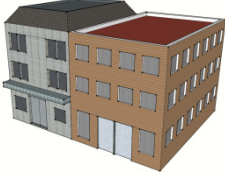
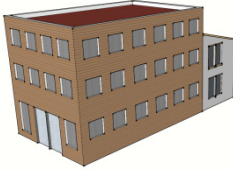
B.7 Level 2 Building Addition Reference Guide

Table B-6 Level 2 Building Addition Reference Guide

Addition Orientation	Type of Addition	Example	RVS Screening Recommendation	Notes and Additional Instructions
Vertical	Single story addition has a smaller footprint than the original building		Evaluate as a single building using the total number of stories of the original building and addition and indicate a setback vertical irregularity.	Vertical setback irregularity applies if the area of the addition is less than 90 percent of the area of the story below or if two or more walls of the addition are not aligned with the walls below.
Vertical	Single or multiple story addition with similar footprint and seismic force-resisting system as the original building		Evaluate as a single building using the total number of stories of the building plus the addition.	If the vertical elements of the seismic force-resisting system of the addition do not align with the vertical elements of the seismic force-resisting system below, apply the setback vertical irregularity.
Vertical	Single or multiple story addition in which the addition has a different seismic force-resisting system		Evaluate as a single building with another observable moderate vertical irregularity.	If the footprint of the addition is less than 90 percent of the story below or if two or more walls of the addition are not aligned with the walls below, a setback vertical irregularity should also be indicated.
Horizontal	Addition with same construction type and number of stories as original and horizontal dimension of the narrower building at the interface is less than or equal to 50% of the length of the wider building		Evaluate as a single building with a torsional irregularity plan irregularity.	If the difference in horizontal dimension is between 50% and 75%, indicate a reentrant corner irregularity. If the floor heights are not aligned within 2 feet, presence of pounding is indicated.
Horizontal	Addition with a different height than the original building		Evaluate as a single building using the height of the taller building and indicate a Pounding Score Modifier if the heights of the buildings differ by more than 2 stories or if the floors do not align with 2 feet.	If the horizontal dimension of the narrower of the two buildings along the interface is less than 75% of the dimension of the wider, the reentrant corner plan irregularity should be indicated.

The above horizontal addition scenarios assume that there is not an obvious separation gap between the addition and the original building.

Table B-6 Level 2 Building Addition Reference Guide (continued)

Addition Orientation	Type of Addition	Example	RVS Screening Recommendation	Notes and Additional Instructions
Horizontal	Addition with different building type than original		Evaluate a single building with torsional irregularity using the building type with the lower basic score.	If the floors do not align within 2 feet or the number of stories differs by more than 2 stories, also indicate the appropriate Pounding Score Modifier.
Horizontal	Small addition where the addition relies on the original building for gravity support		Evaluate as a single building. Evaluate for the presence of a setback irregularity if there is a difference in the number of stories and plan irregularity if there is a difference in horizontal dimension of the original building and addition along the interface.	If the construction type of the addition is different than the original building, evaluate as two buildings with the addition as having an observable severe vertical irregularity.

The above horizontal addition scenarios assume that there is not an obvious separation gap between the addition and the original building.

FEMA E-74 NONSTRUCTURAL SEISMIC BRACING EXCERPTS

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Life Safety Systems

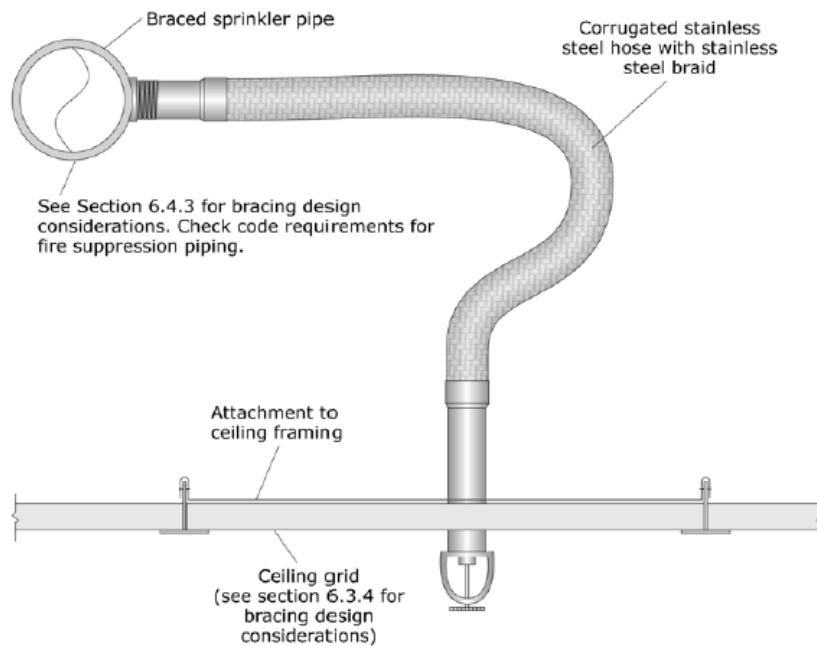


Figure G-1. Flexible Sprinkler Drop.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

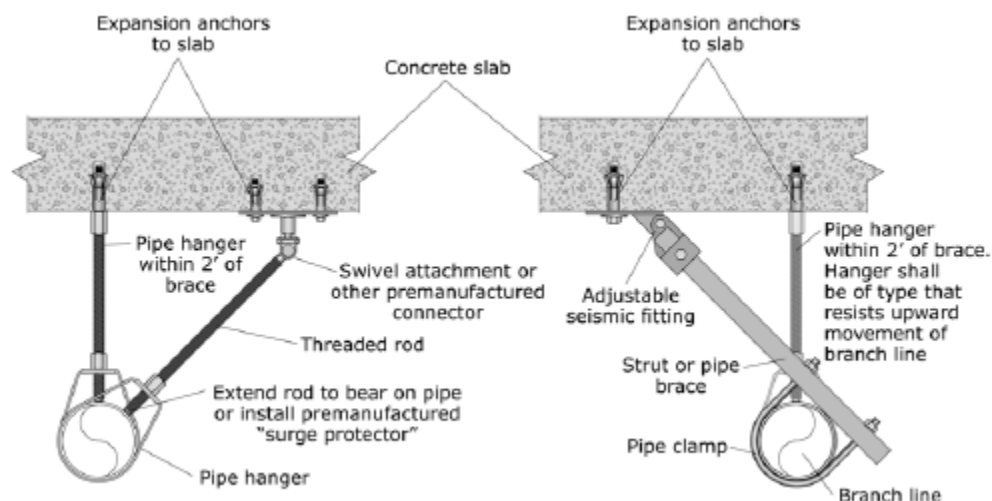


Figure G-2. End of Line Restraint.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Partitions

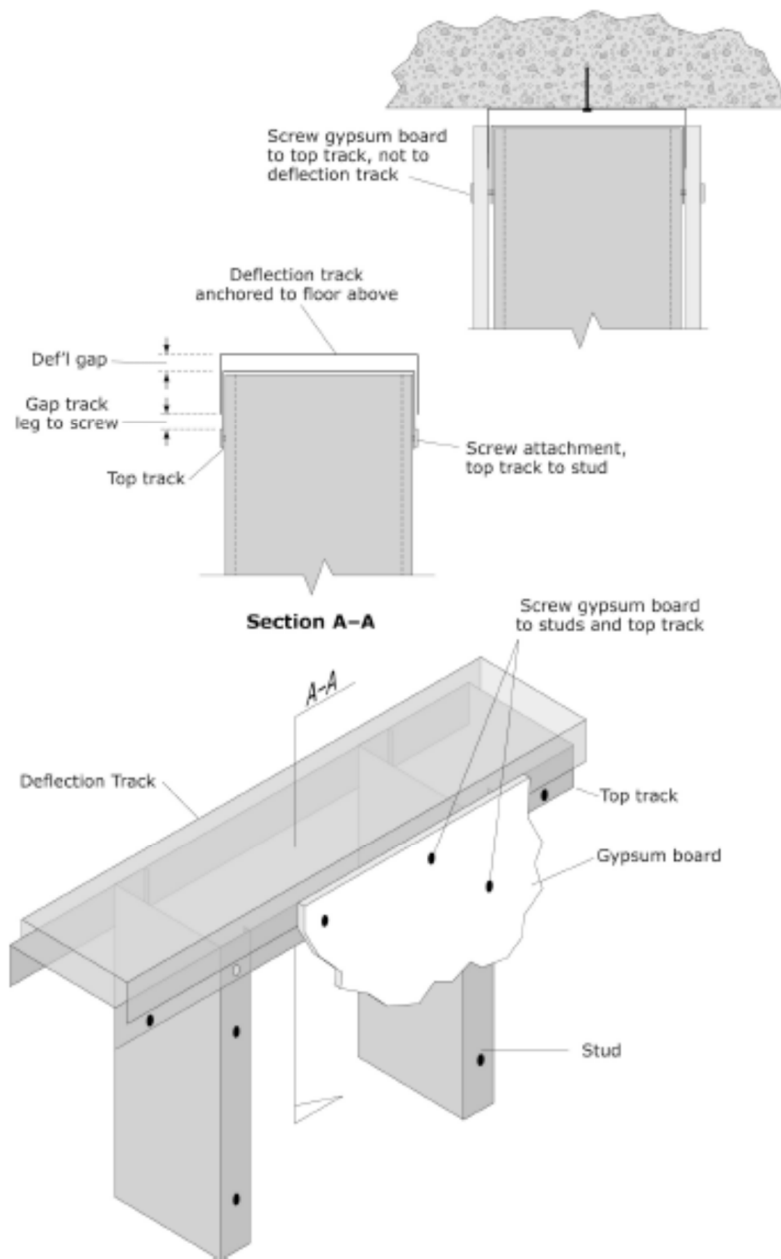


Figure G-3. Mitigation Schemes for Bracing the Tops of Metal Stud Partitions Walls.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)

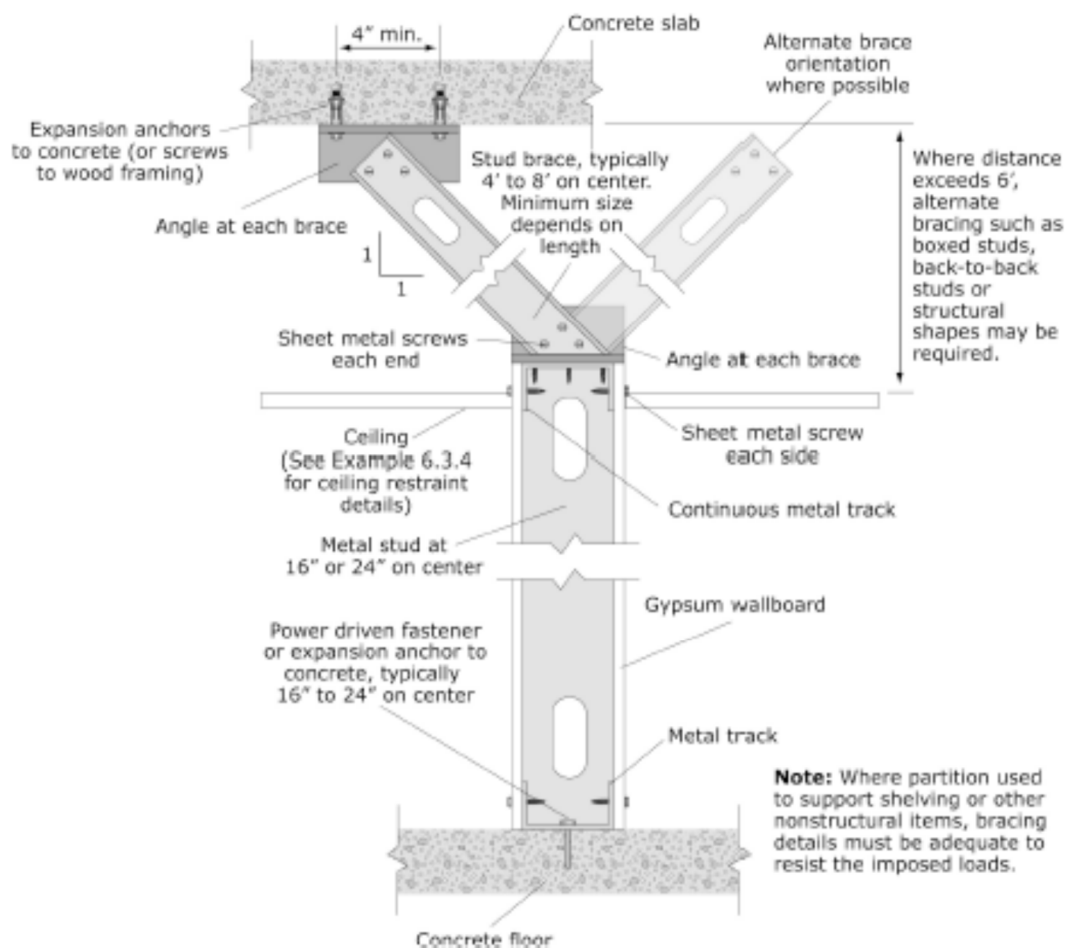


Figure G-4. Mitigation Schemes for Bracing the Tops of Metal Stud Partition Walls.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

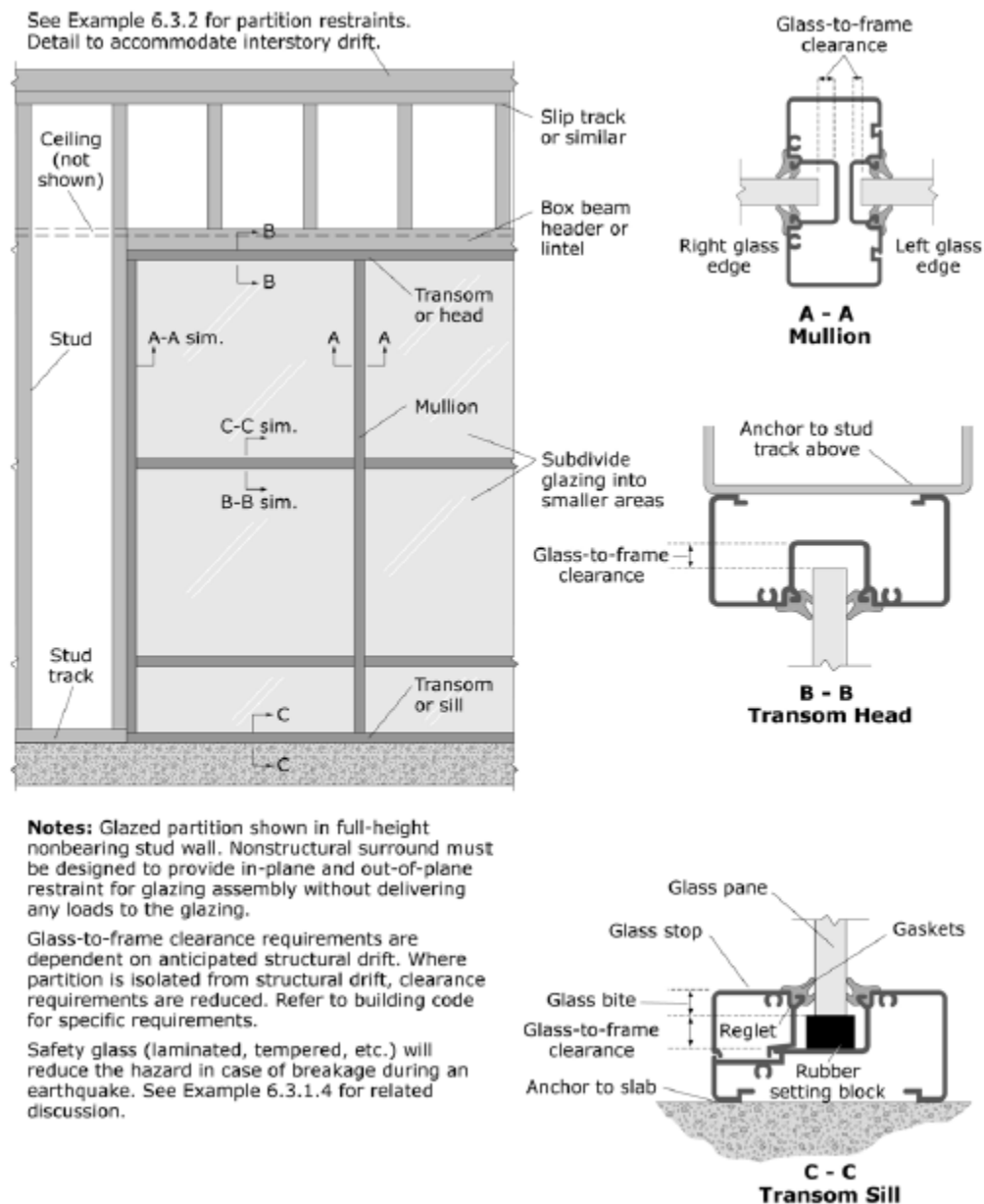


Figure G-5. Full-height Glazed Partition.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

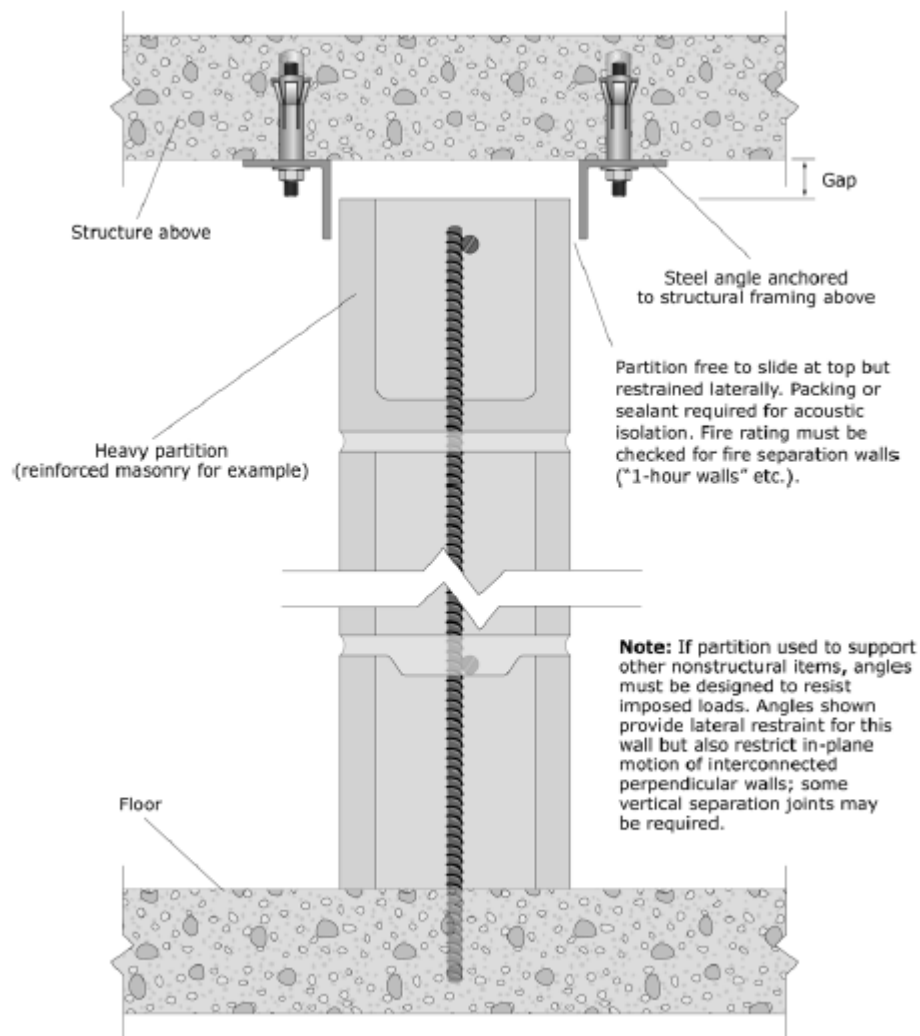


Figure G-6. Full-height Heavy Partition.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

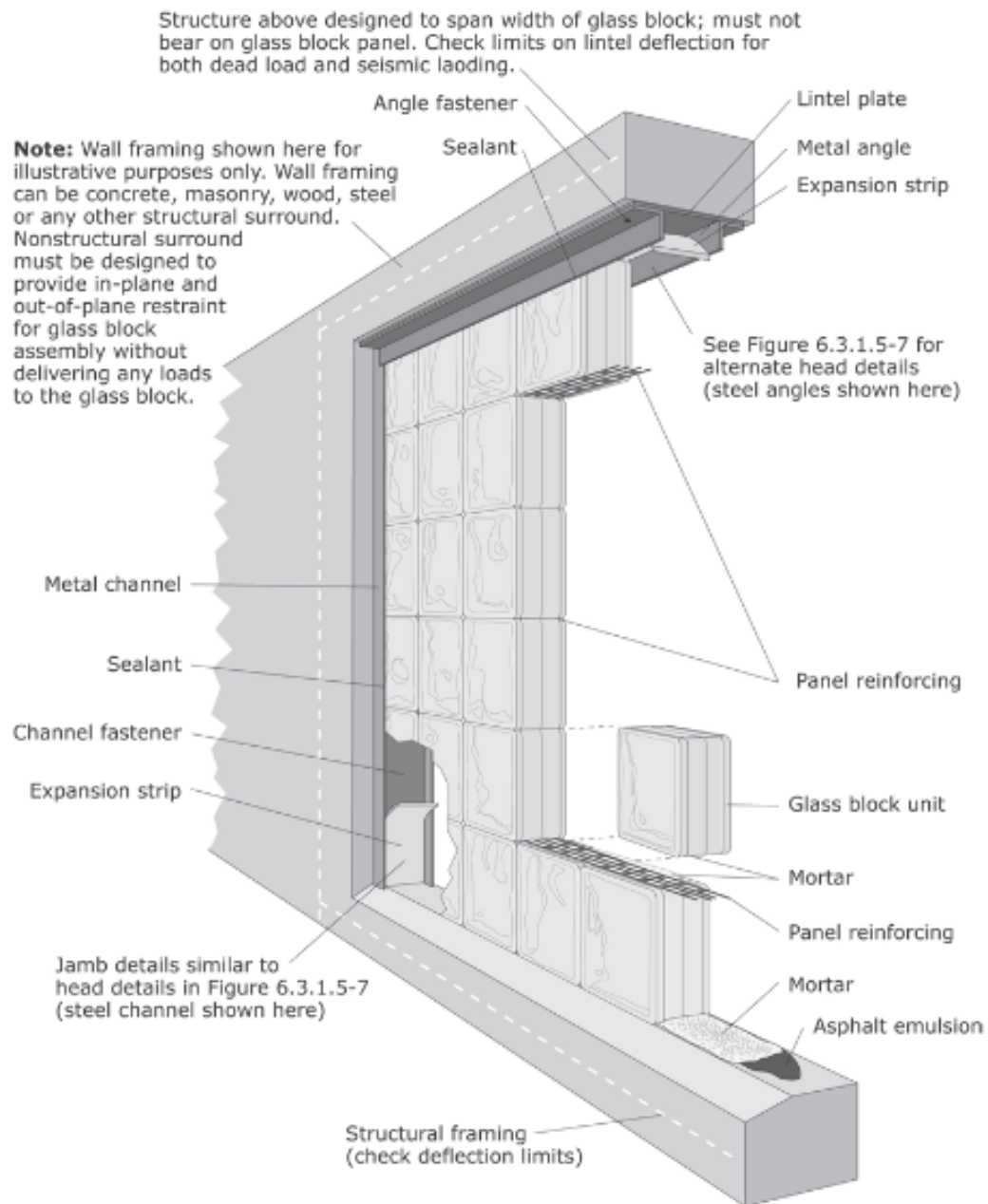
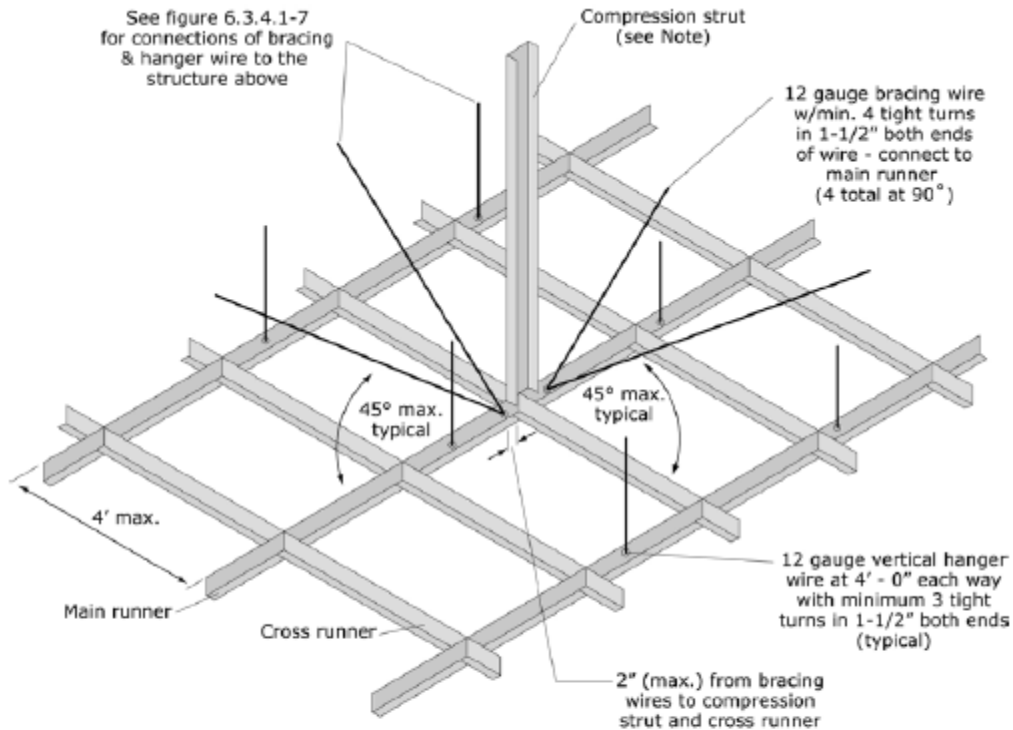


Figure G-7. Typical Glass Block Panel Details.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Washington State School Seismic Safety Assessments Project





Note: Compression strut shall not replace hanger wire. Compression strut consists of a steel section attached to main runner with 2 - #12 sheet metal screws and to structure with 2 - #12 screws to wood or 1/4" min. expansion anchor to structure. Size of strut is dependent on distance between ceiling and structure ($l/r \leq 200$). A 1" diameter conduit can be used for up to 6'; a 1-5/8" X 1-1/4" metal stud can be used for up to 10'

Per DSA IR 25-5, ceiling areas less than 144 sq. ft., or fire rated ceilings less than 96 sq. ft., surrounded by walls braced to the structure above do not require lateral bracing assemblies when they are attached to two adjacent walls. (ASTM E580 does not require lateral bracing assemblies for ceilings less than 1000 sq. ft.; see text.)

Figure G-9. Suspension System for Acoustic Lay-in Panel Ceilings – General Bracing Assembly.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)

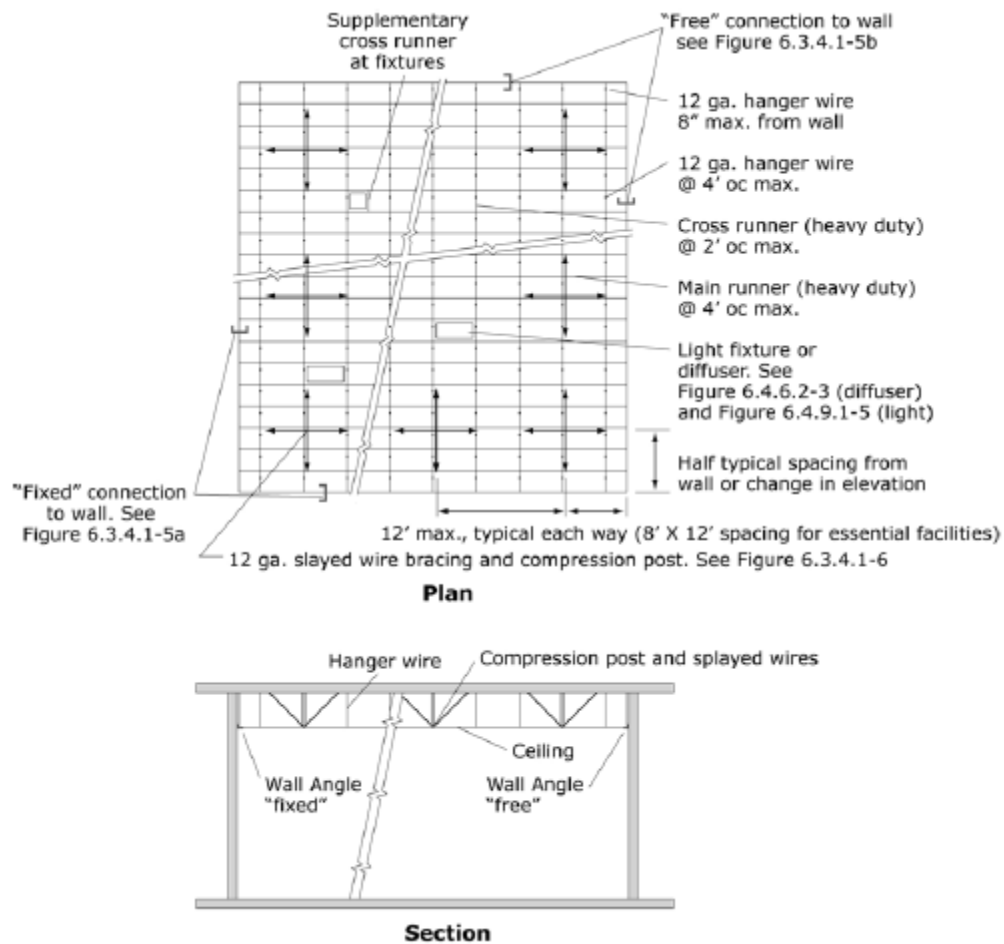


Figure G-10. Suspension System for Acoustic Lay-in Panel Ceilings – General Bracing Layout.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

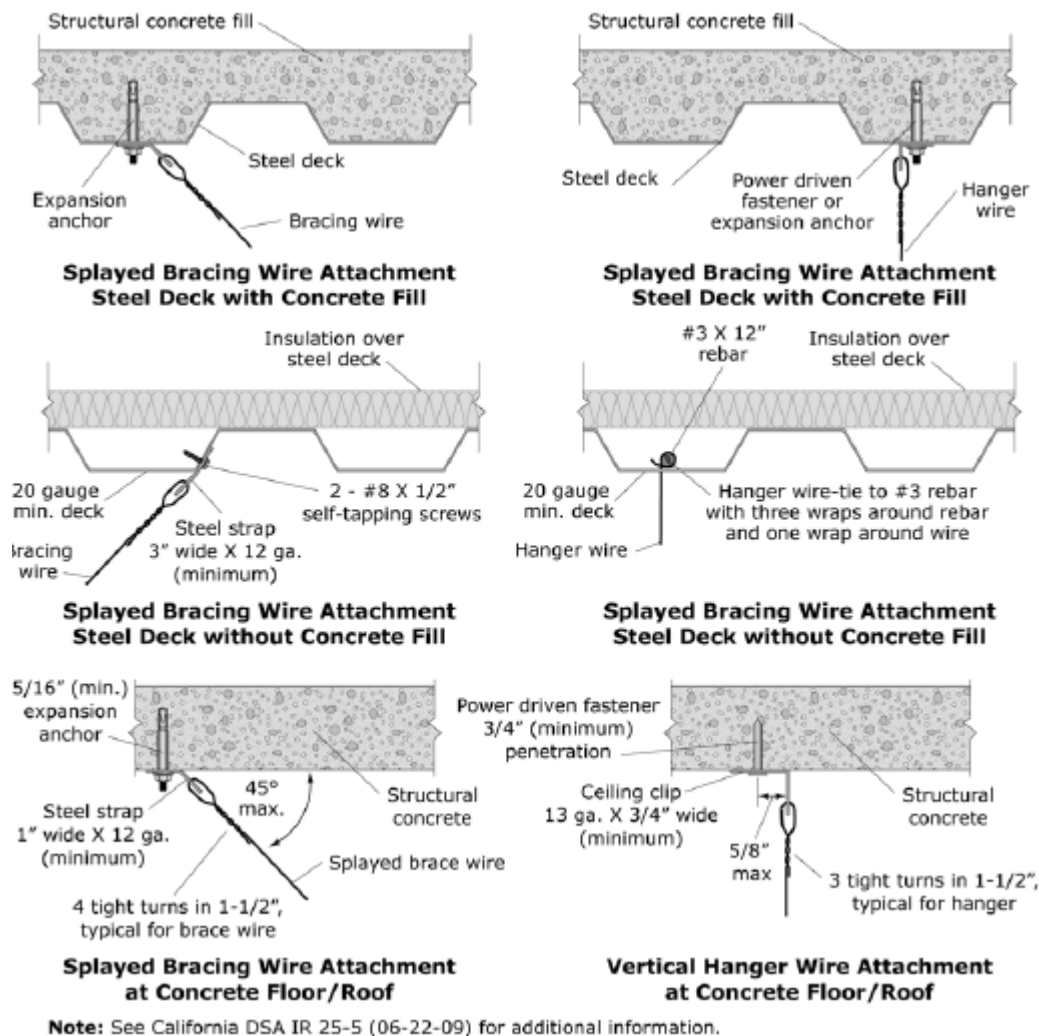
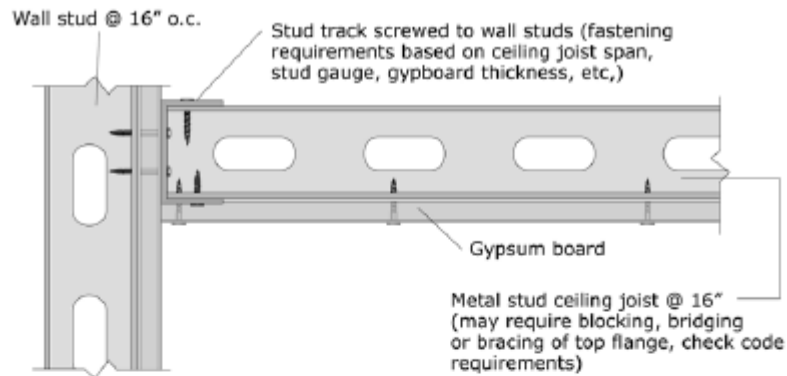
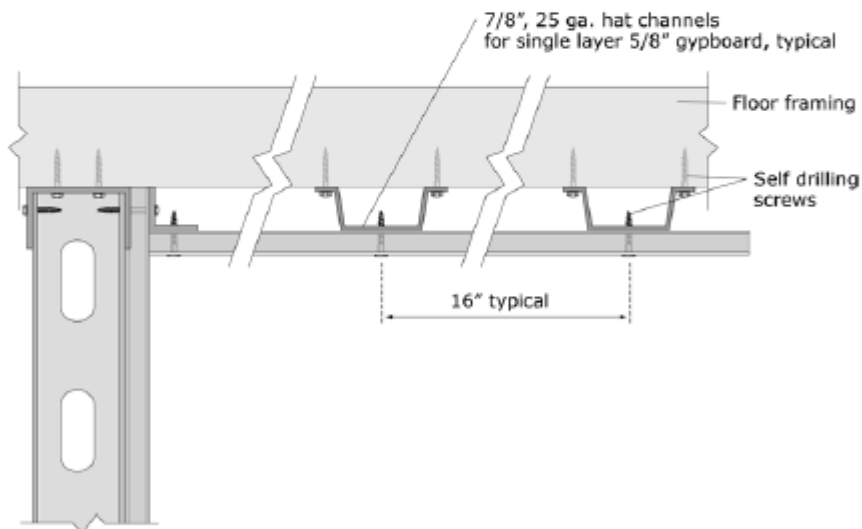


Figure G-11. Suspension System for Acoustic Lay-in Panel Ceilings – Overhead Attachment Details.

(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



a) Gypsum board attached directly to ceiling joists



b) Gypsum board attached directly to furring strips (hat channel or similar)

Note: Commonly used details shown; no special seismic details are required as long as furring and gypboard secured. Check for certified assemblies (UL listed, FM approved, etc.) if fire or sound rating required.

Figure G-12. Gypsum Board Ceiling Applied Directly to Structure.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)

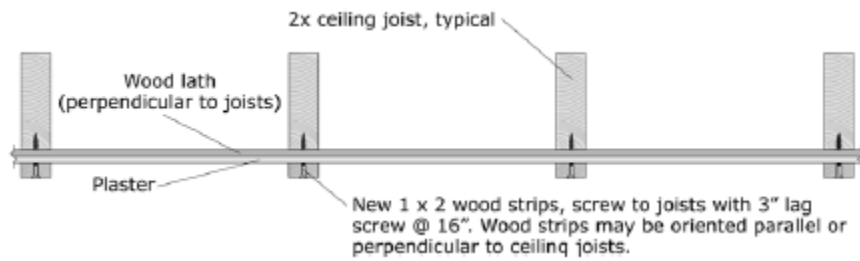


Figure G-13. Retrofit Detail for Existing Lath and Plaster.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

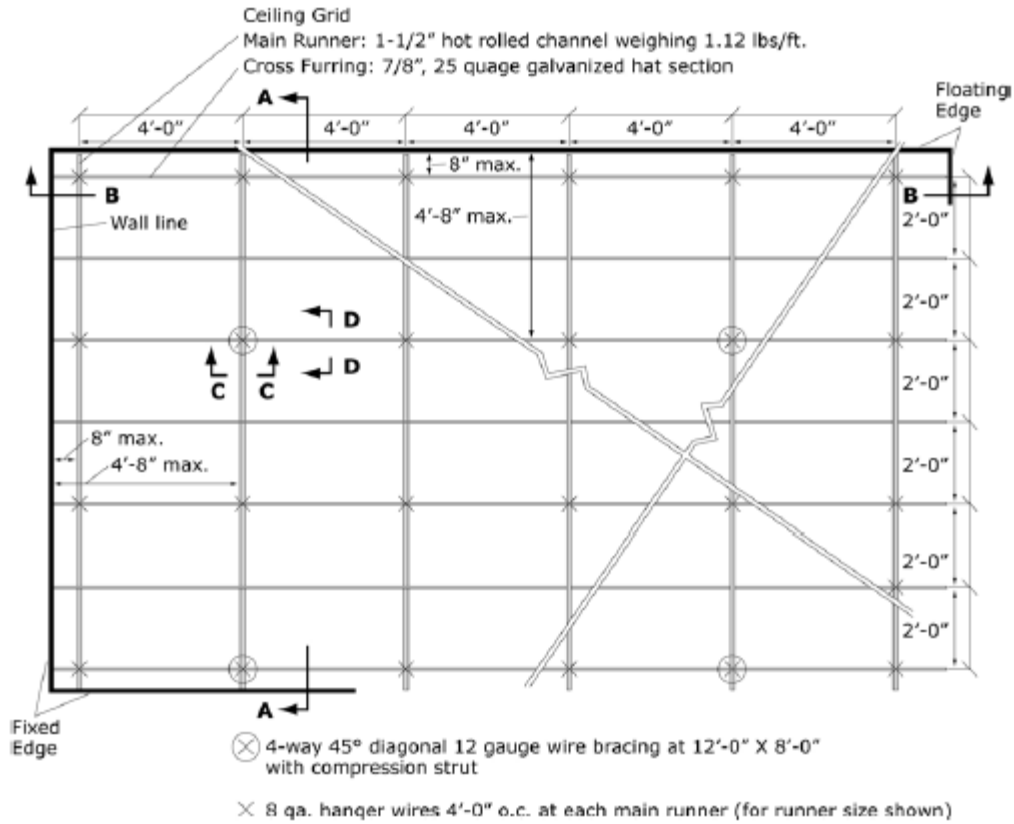
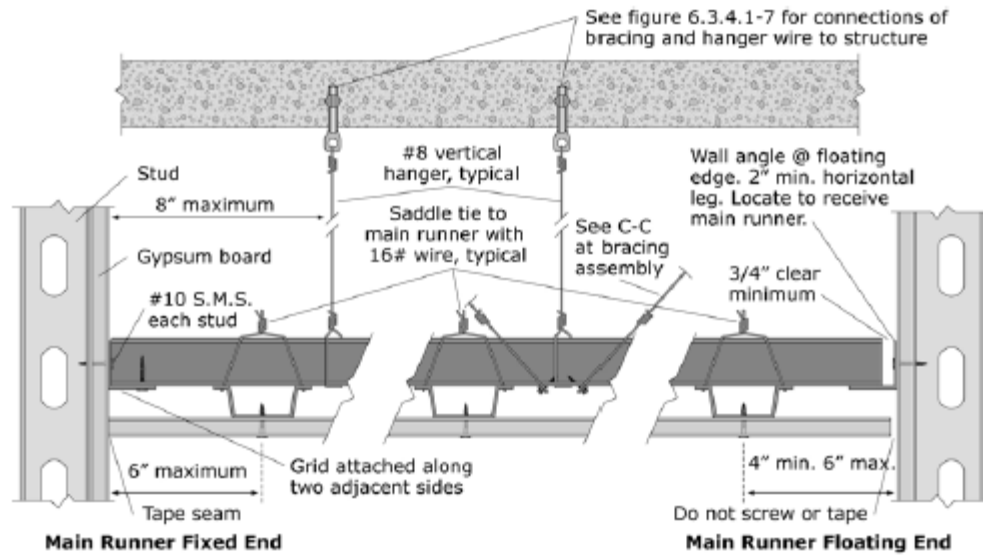
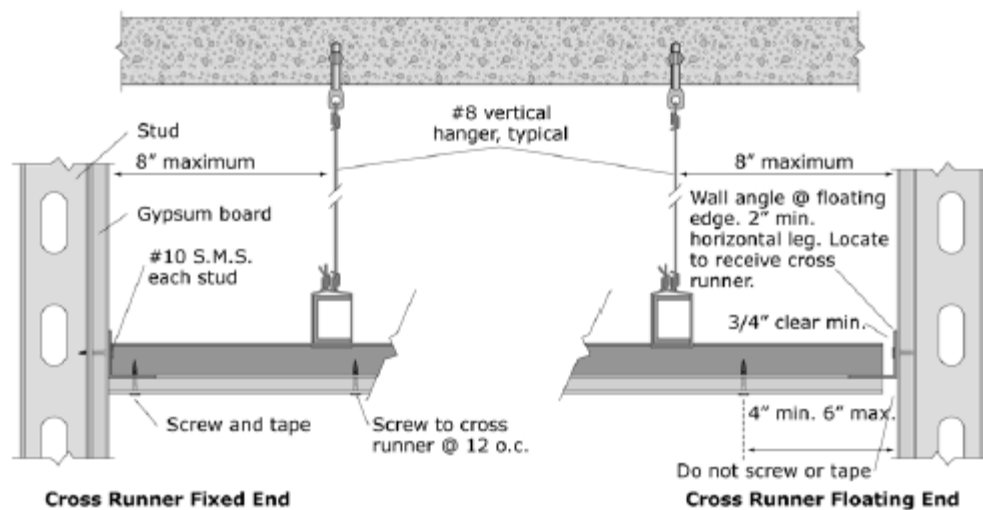


Figure G-14. Diagrammatic View of Suspended Heavy Ceiling Grid and Lateral Bracing.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)

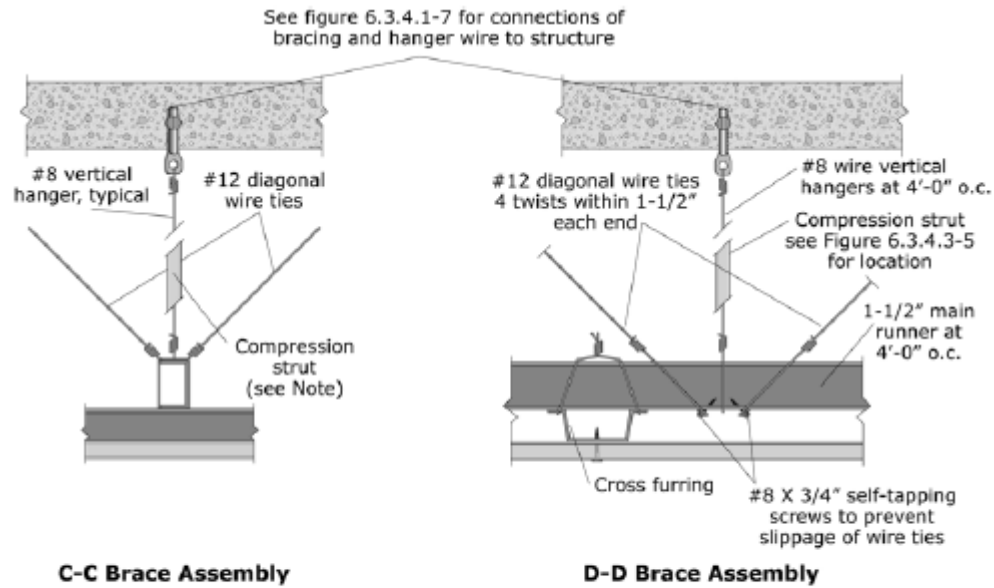


A-A Main Runner at Perimeter



B-B Cross Runner at Perimeter

Figure G-15. Perimeter Details for Suspended Gypsum Board Ceiling.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Note: Compression strut shall not replace hanger wire. Compression strut consists of a steel section attached to main runner with 2 - #12 sheet metal screws and to structure with 2 - #12 screws to wood or 1/4" min. expansion anchor to concrete. Size of strut is dependent on distance between ceiling and structure ($l/r \leq 200$). A 1" diameter conduit can be used for up to 6', a 1-5/8" X 1-1/4" metal stud can be used for up to 10'. See figure 6.3.4.1-6 for example of bracing assembly.

Figure G-16. Details for Lateral Bracing Assembly for Suspended Gypsum Board Ceiling.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)

Light Fixtures

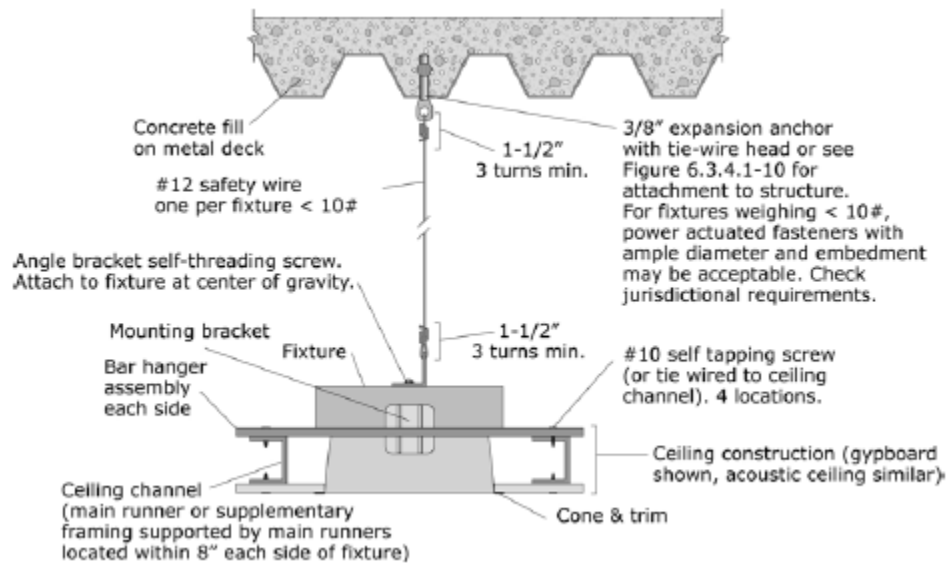


Figure G-17. Recessed Light Fixture in suspended Ceiling (Fixture Weight < 10 pounds).
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

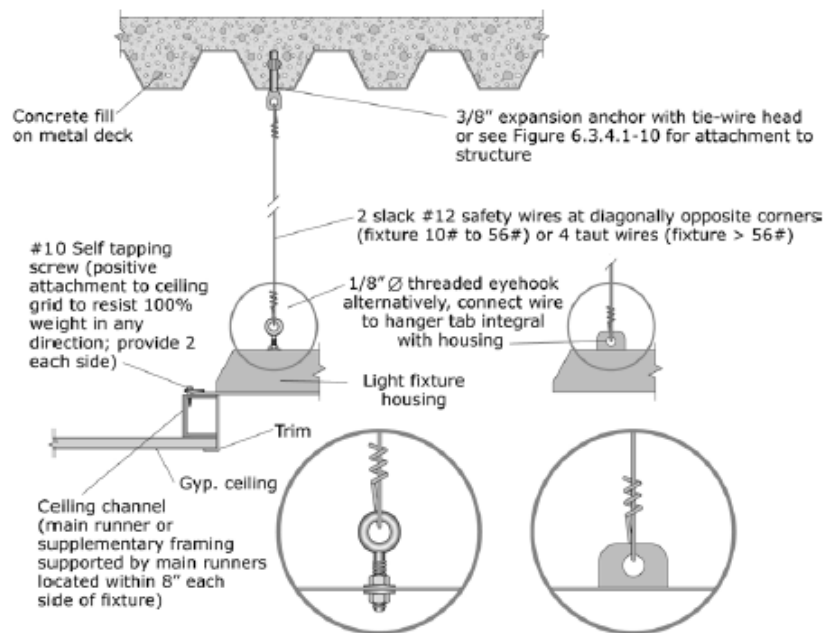


Figure G-18. Recessed Light Fixture in suspended Ceiling (Fixture Weight 10 to 56 pounds).
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Contents and Furnishings

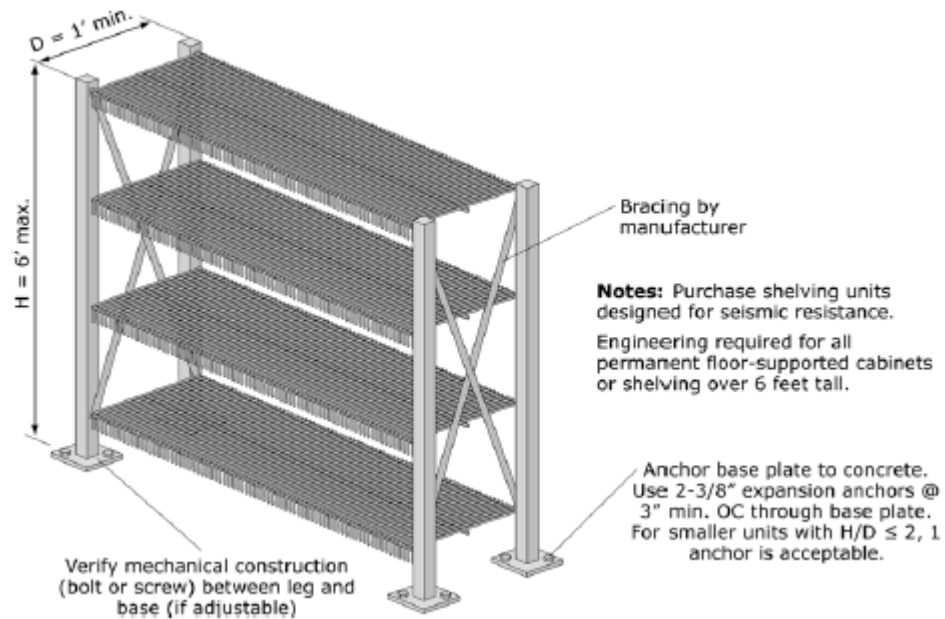
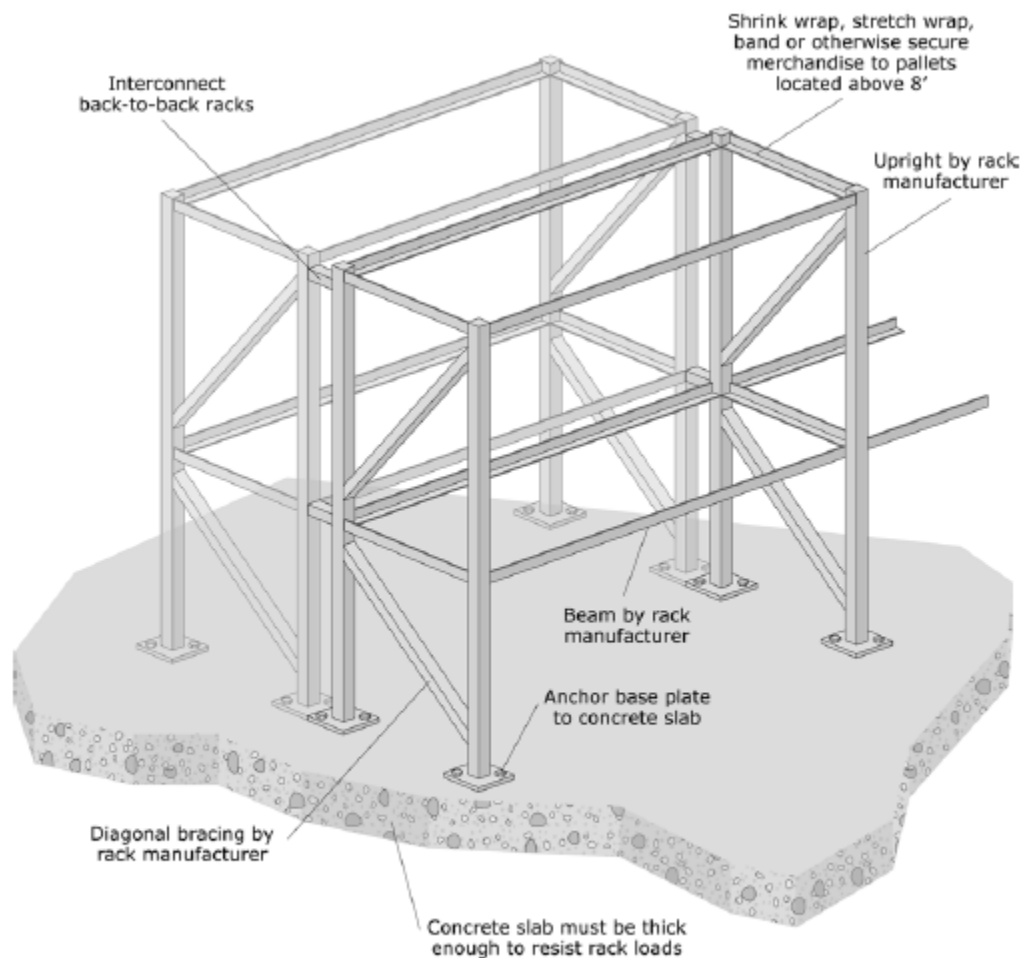


Figure G-19. Light Storage Racks.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)



Note: Purchase storage racks designed for seismic resistance. Storage racks may be classified as either nonstructural elements or nonbuilding structures depending upon their size and support conditions. Check the applicable code to see which provisions apply.

Figure G-20. Industrial Storage Racks.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

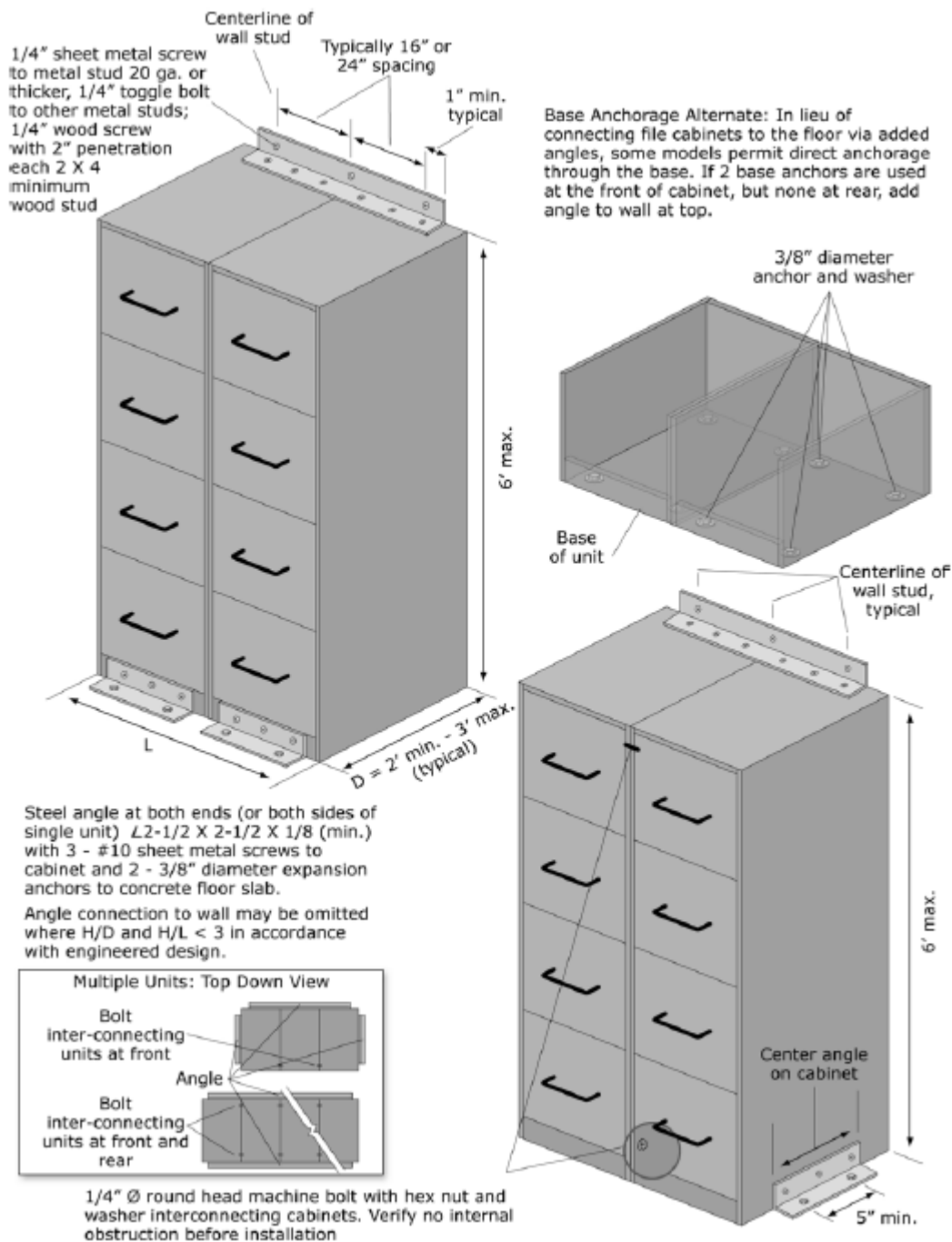


Figure G-21. Wall-mounted File Cabinets.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

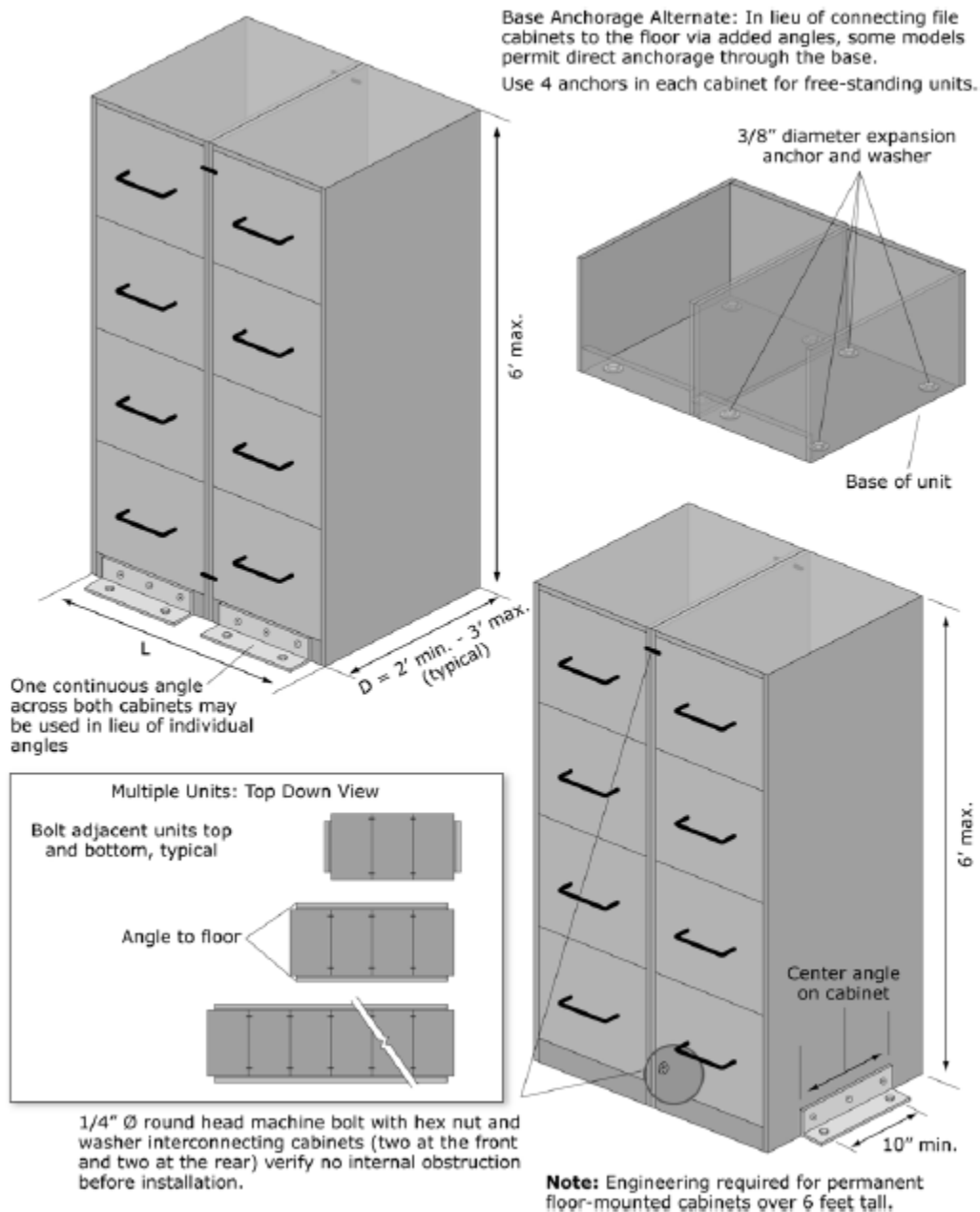
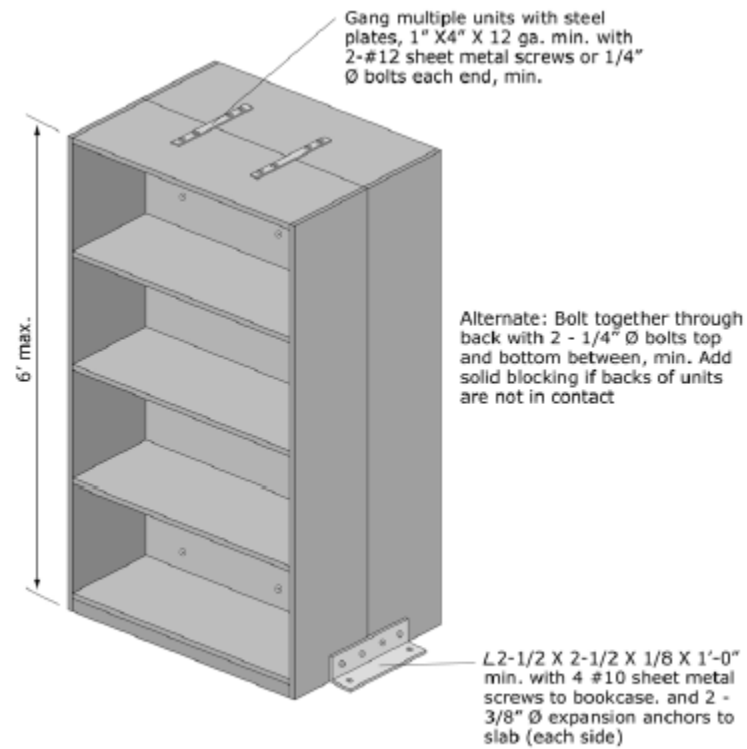


Figure G-22. Base Anchored File Cabinets.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



Note: Engineering required for all permanent floor-supported cabinets or shelving over 6 feet tall. Details shown are adequate for typical shelving 6 feet or less in height.

Figure G-23. Anchorage of Freestanding Book Cases Arranged Back to Back.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

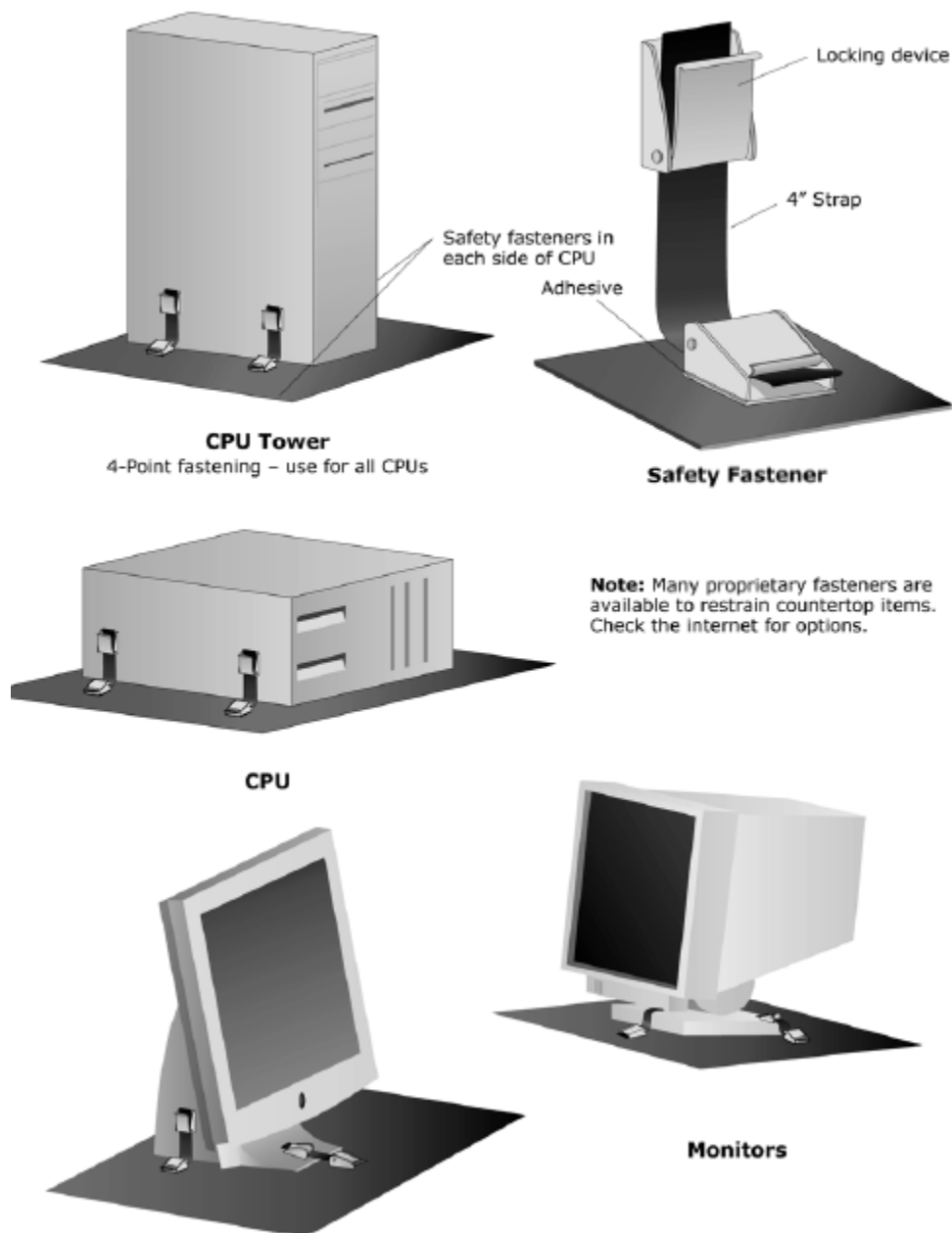
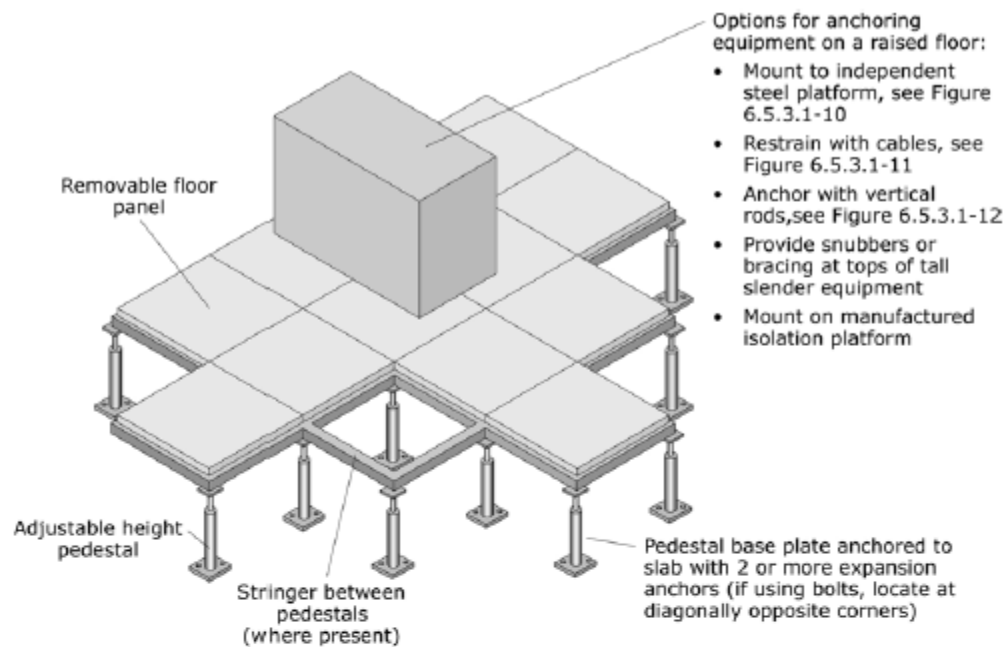
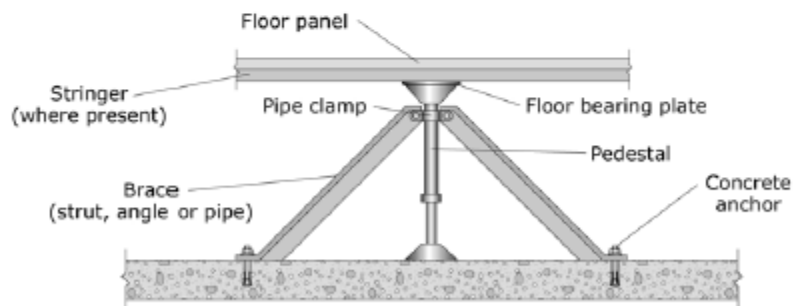


Figure G-24. Desktop Computers and Accessories.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)



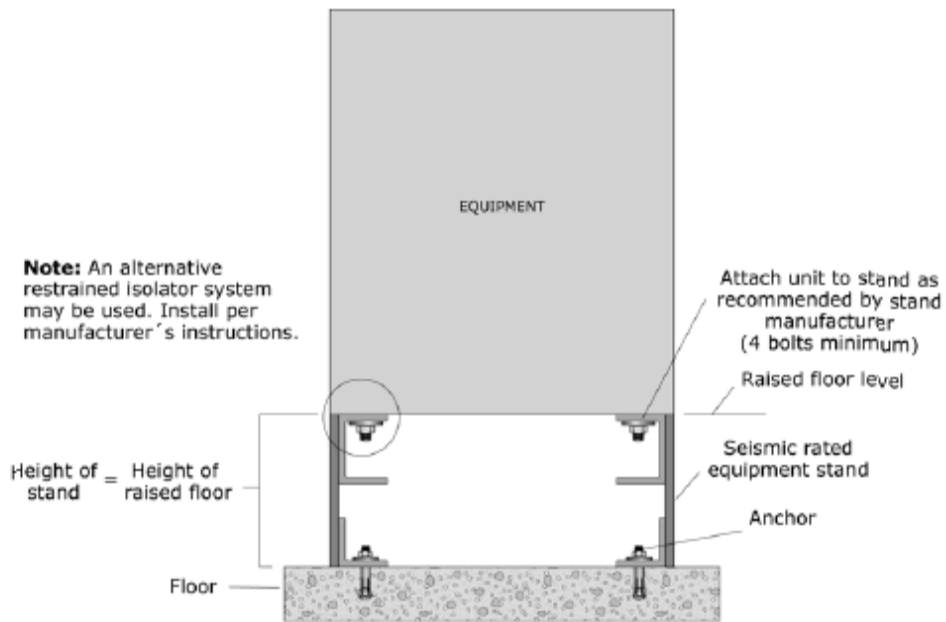
Cantilevered Access Floor Pedestal



Braced Access Floor Pedestal (use for tall floors or where pedestals are not strong enough to resist seismic forces)

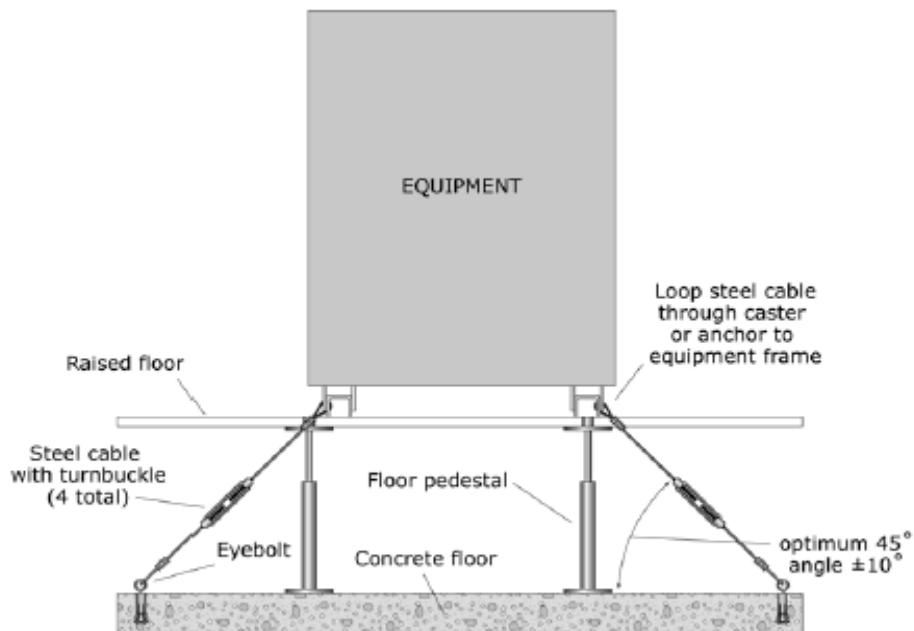
Note: For new floors in areas of high seismicity, purchase and install systems that meet the applicable code provisions for "special access floors."

Figure G-25. Equipment Mounted on Access Floor.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)



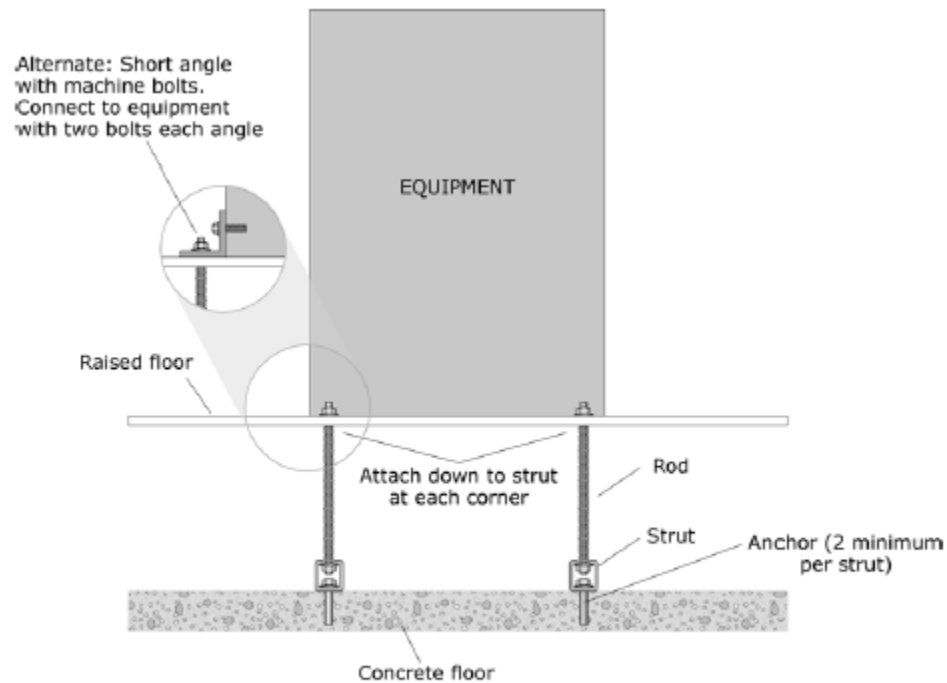
Equipment installed on an independent steel platform within a raised floor

Figure G-26. Equipment Mounted on Access Floor – Independent Base.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)



Equipment restrained with cables beneath a raised floor

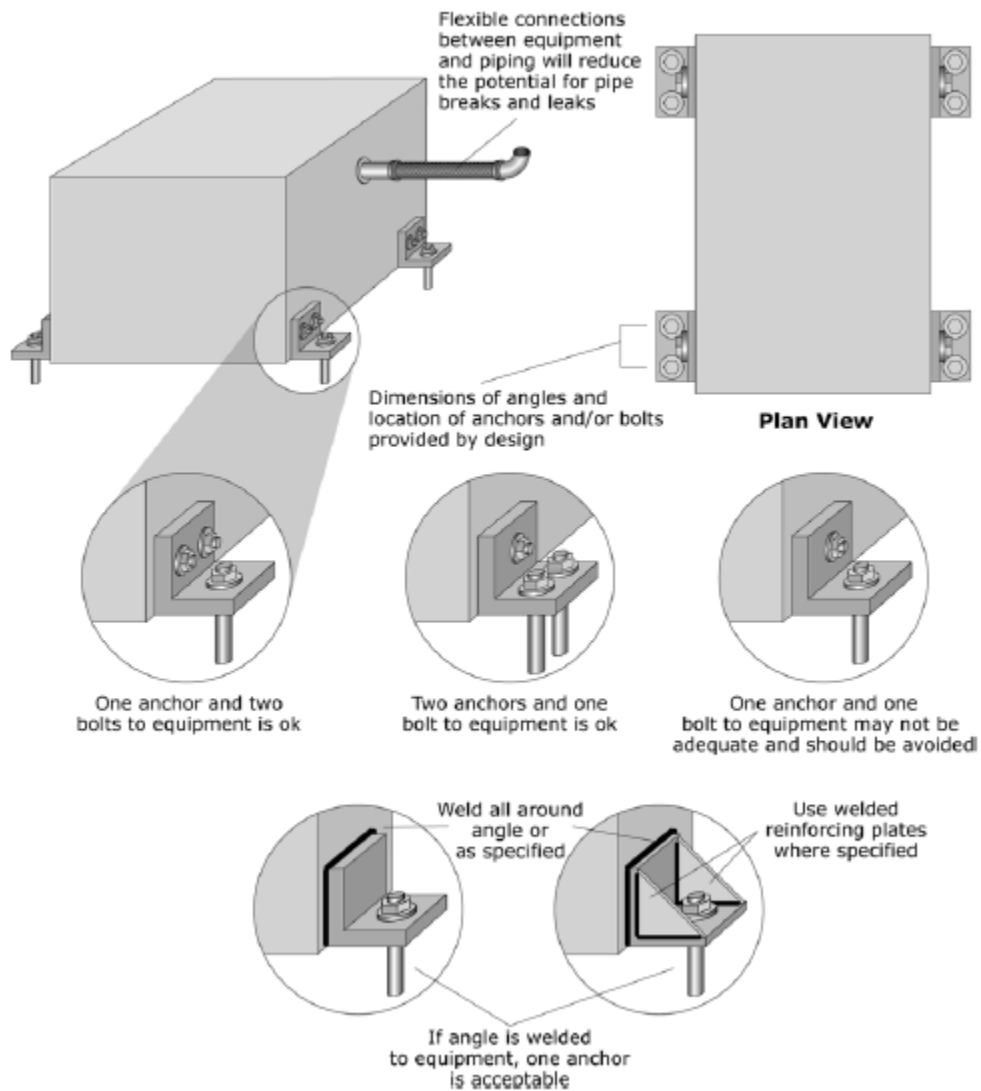
Figure G-27. Equipment Mounted on Access Floor – Cable Braced.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)



Equipment anchored with vertical rods beneath a raised floor

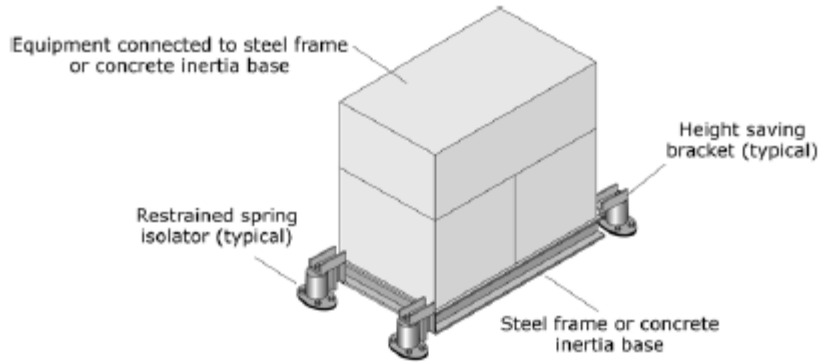
Figure G-28. Equipment Mounted on Access Floor – Tie-down Rods.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Mechanical and Electrical Equipment

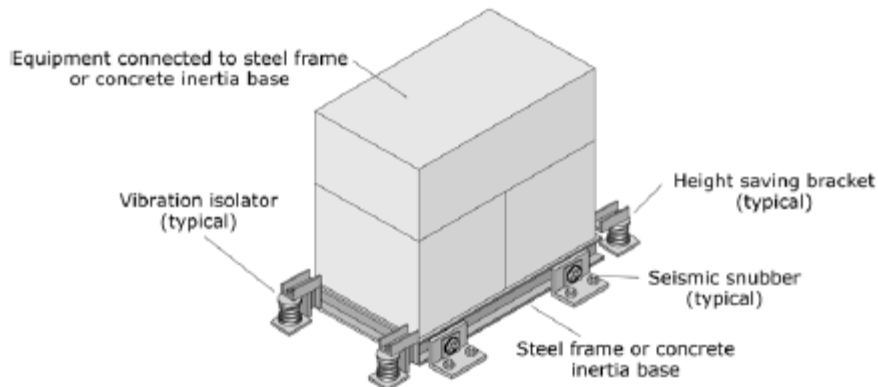


Note: Rigidly mounted equipment shall have flexible connections for the fuel lines and piping.

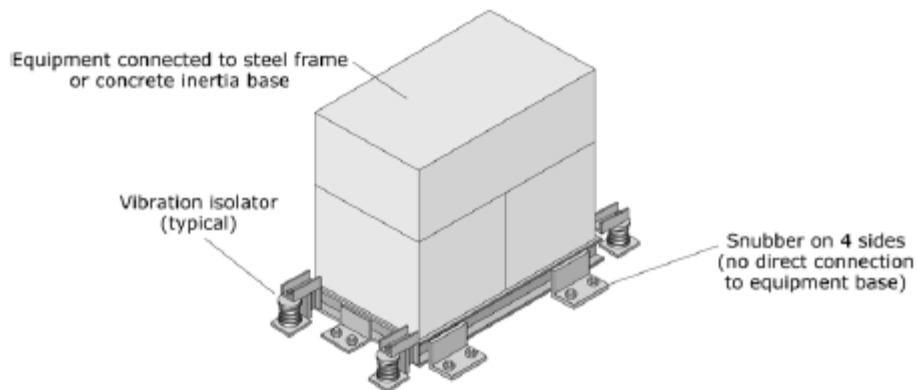
Figure G-29. Rigidly Floor-mounted Equipment with Added Angles.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)



Supplemental base with restrained spring isolators



Supplemental base with open springs and all-directional snubbers



Supplemental base with open springs and one-directional snubbers

Figure G-30. HVAC Equipment with Vibration Isolation.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

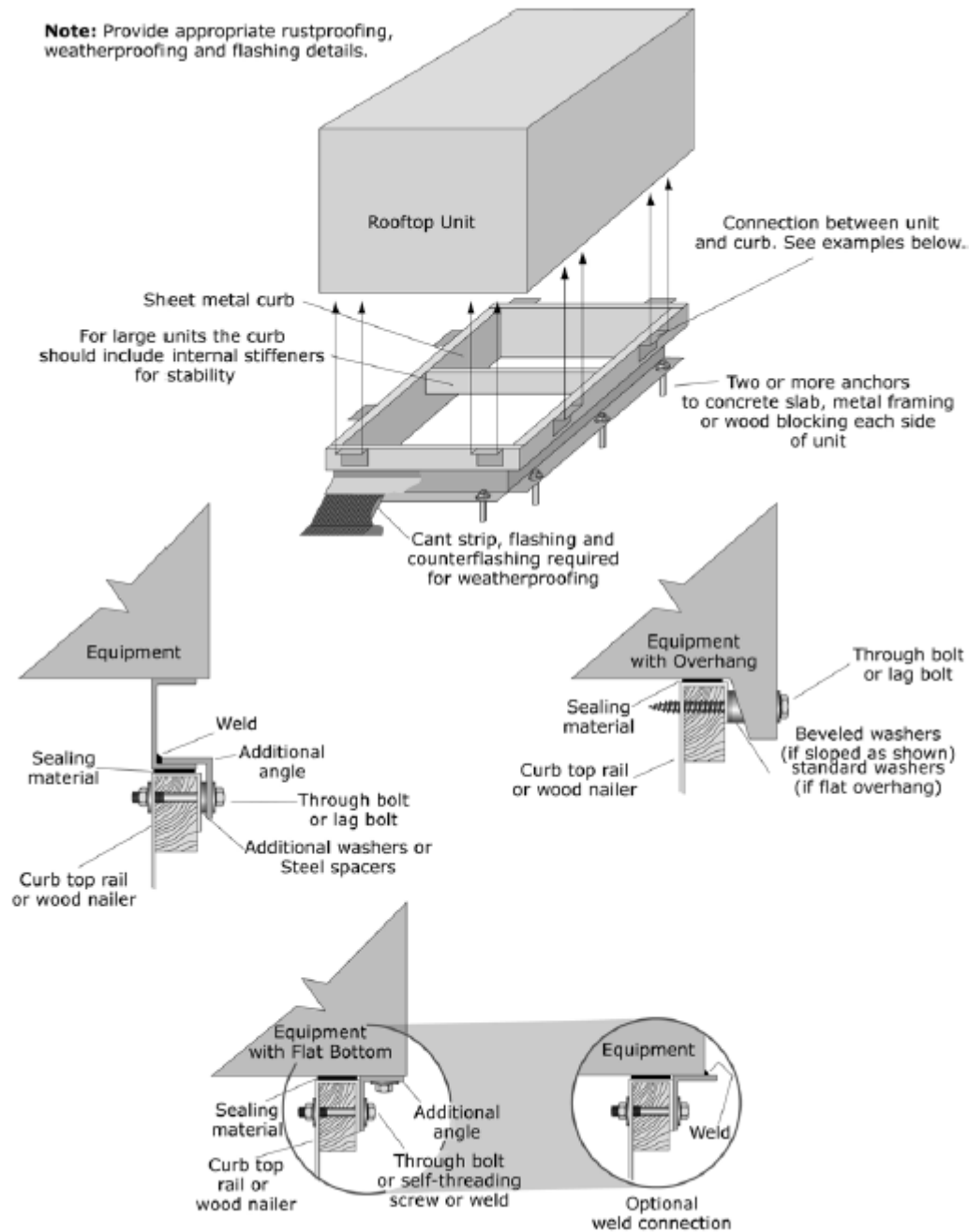


Figure G-31. Rooftop HVAC Equipment.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

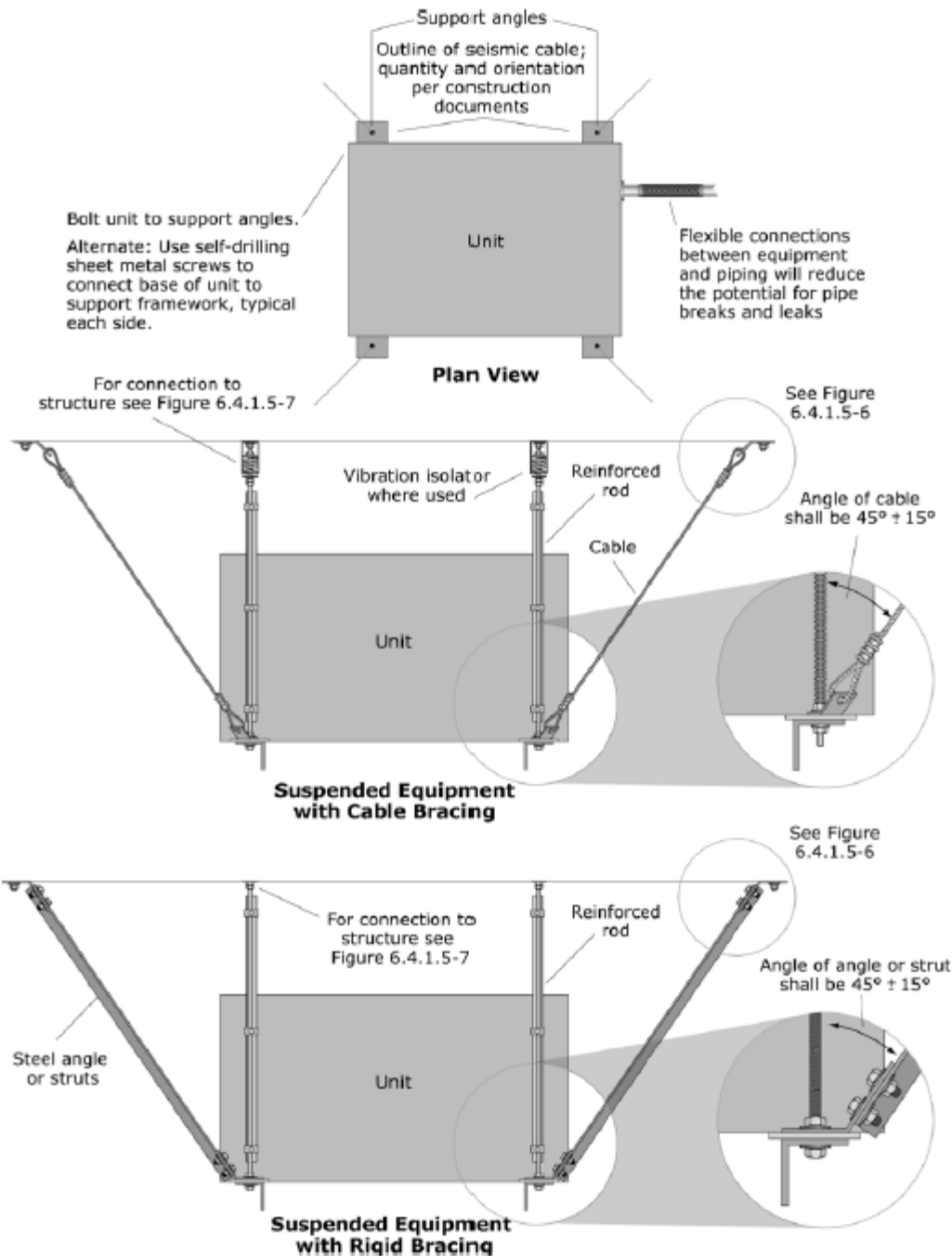


Figure G-32. Suspended Equipment.
 (FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)

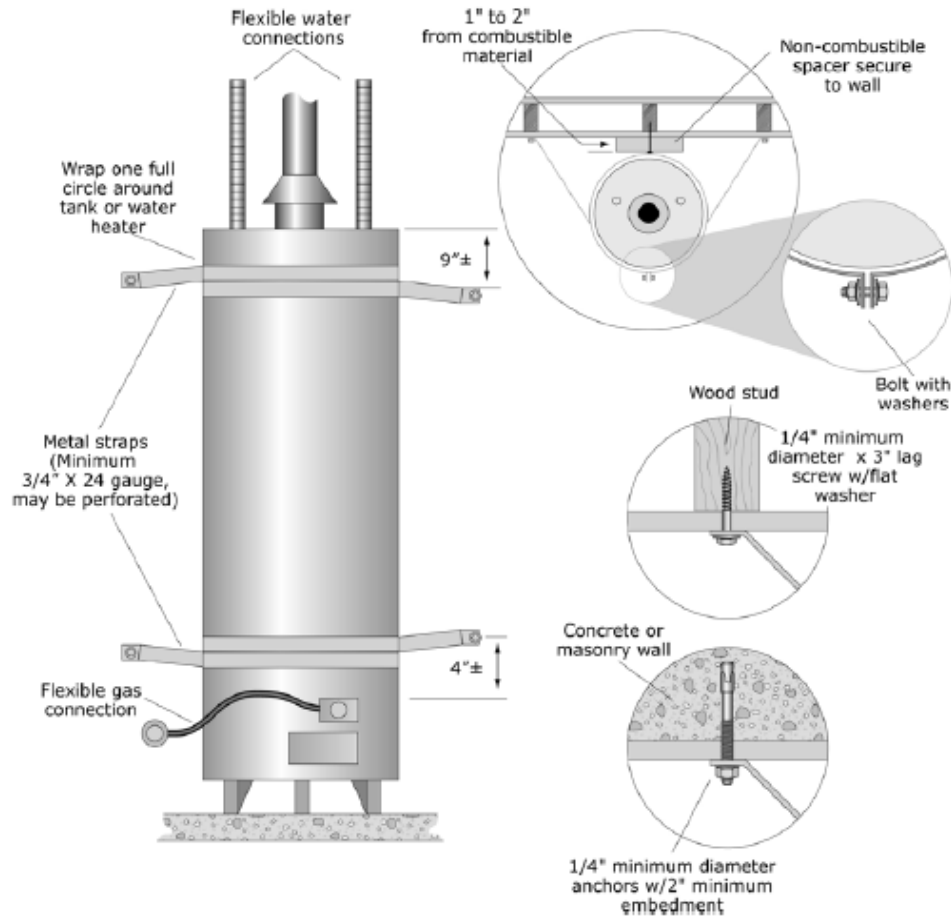


Figure G-33. Water Heater Strapping to Backing Wall.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

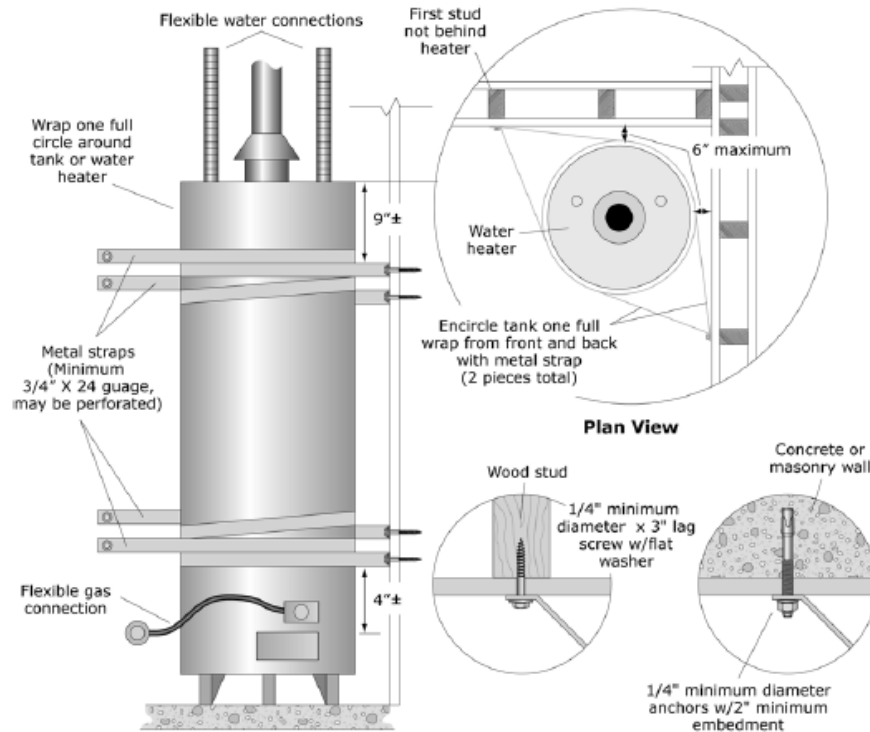


Figure G-34. Water Heater – Strapping at Corner Installation.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

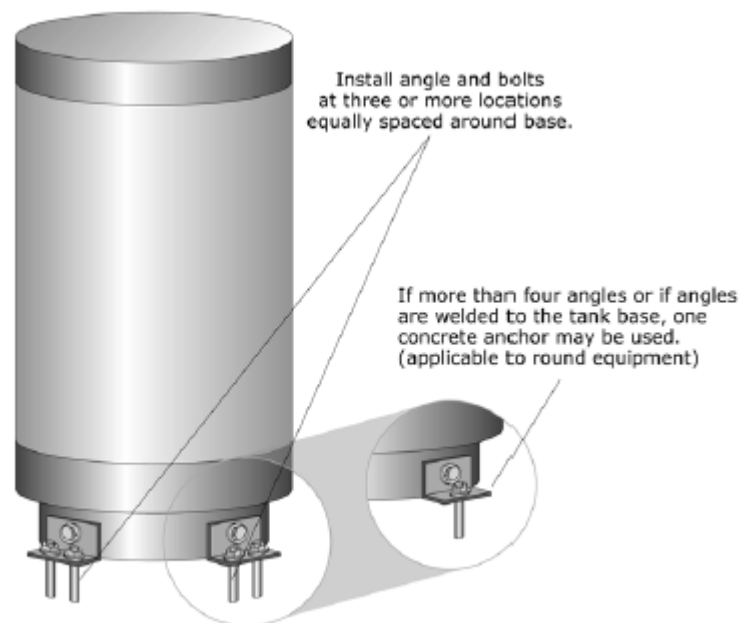


Figure G-35. Water Heater – Base Mounted.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

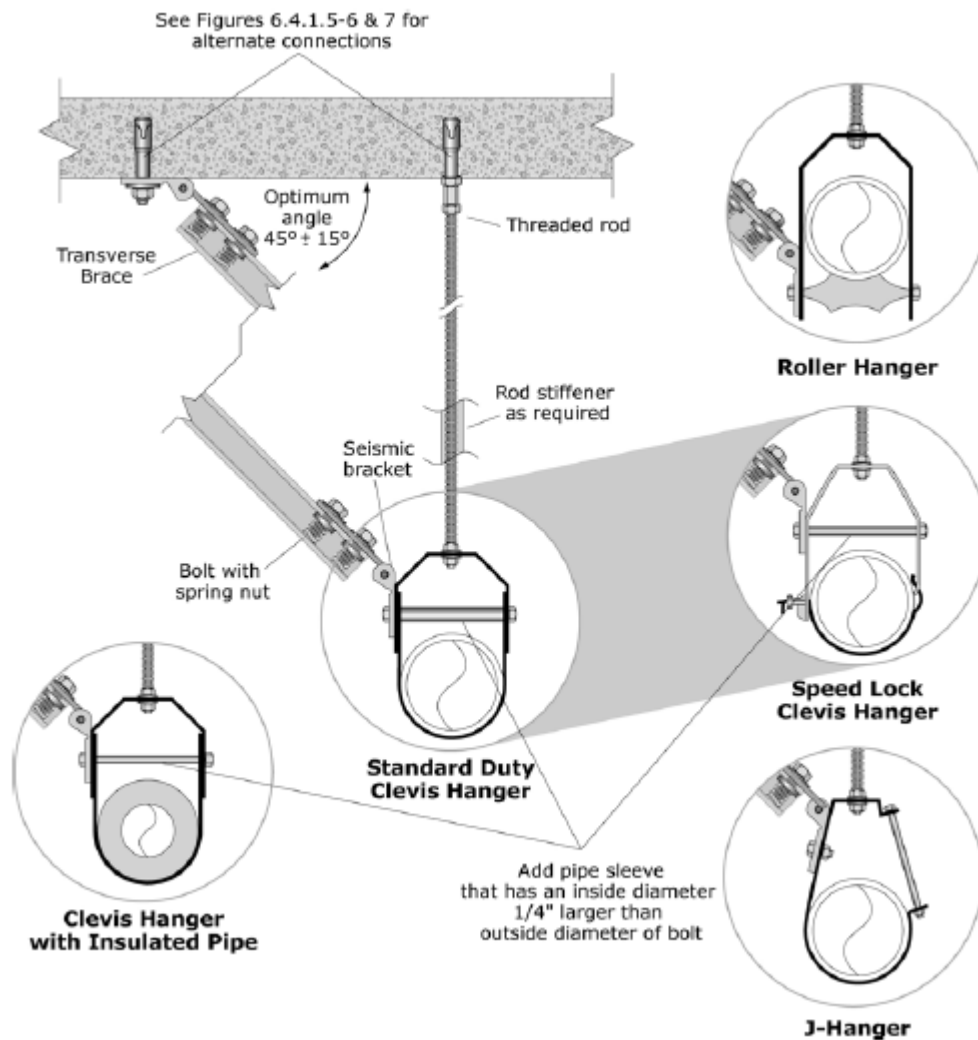


Figure G-36. Rigid Bracing – Single Pipe Transverse.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

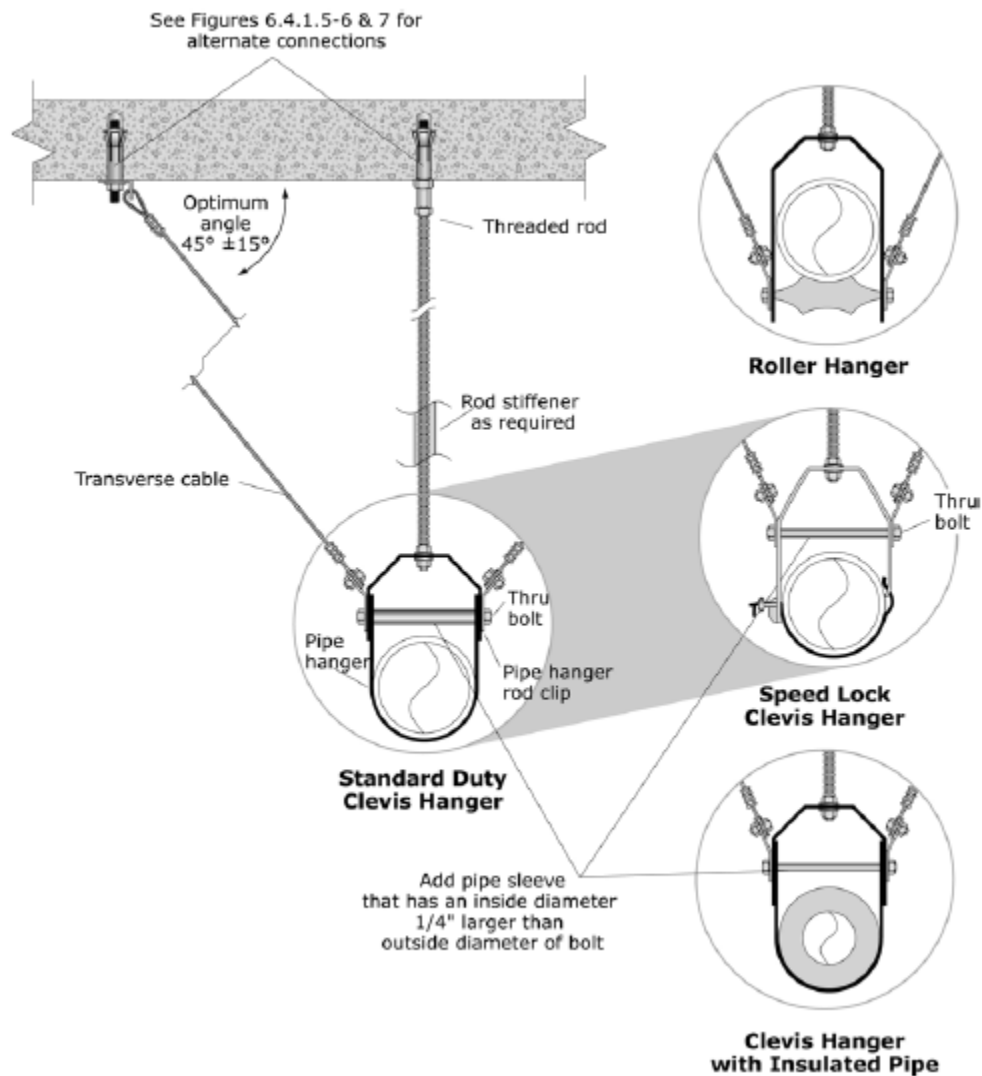


Figure G-37. Cable Bracing – Single Pipe Transverse.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

Electrical and Communications

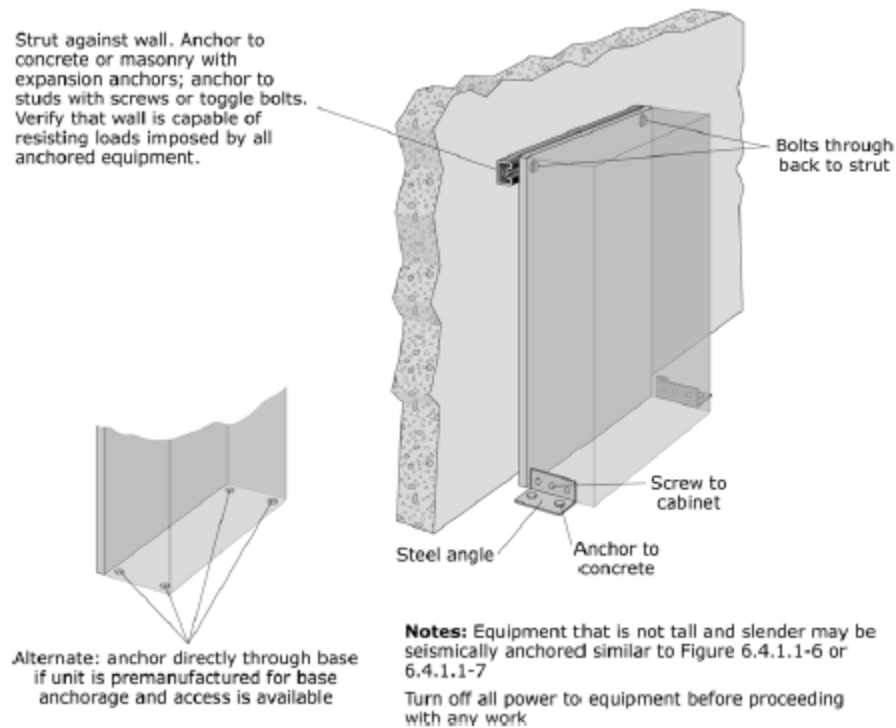


Figure G-38. Electrical Control Panels, Motor Controls Centers, or Switchgear.
(FEMA E-74, 2012, *Reducing the Risks of Nonstructural Earthquake Damage*)

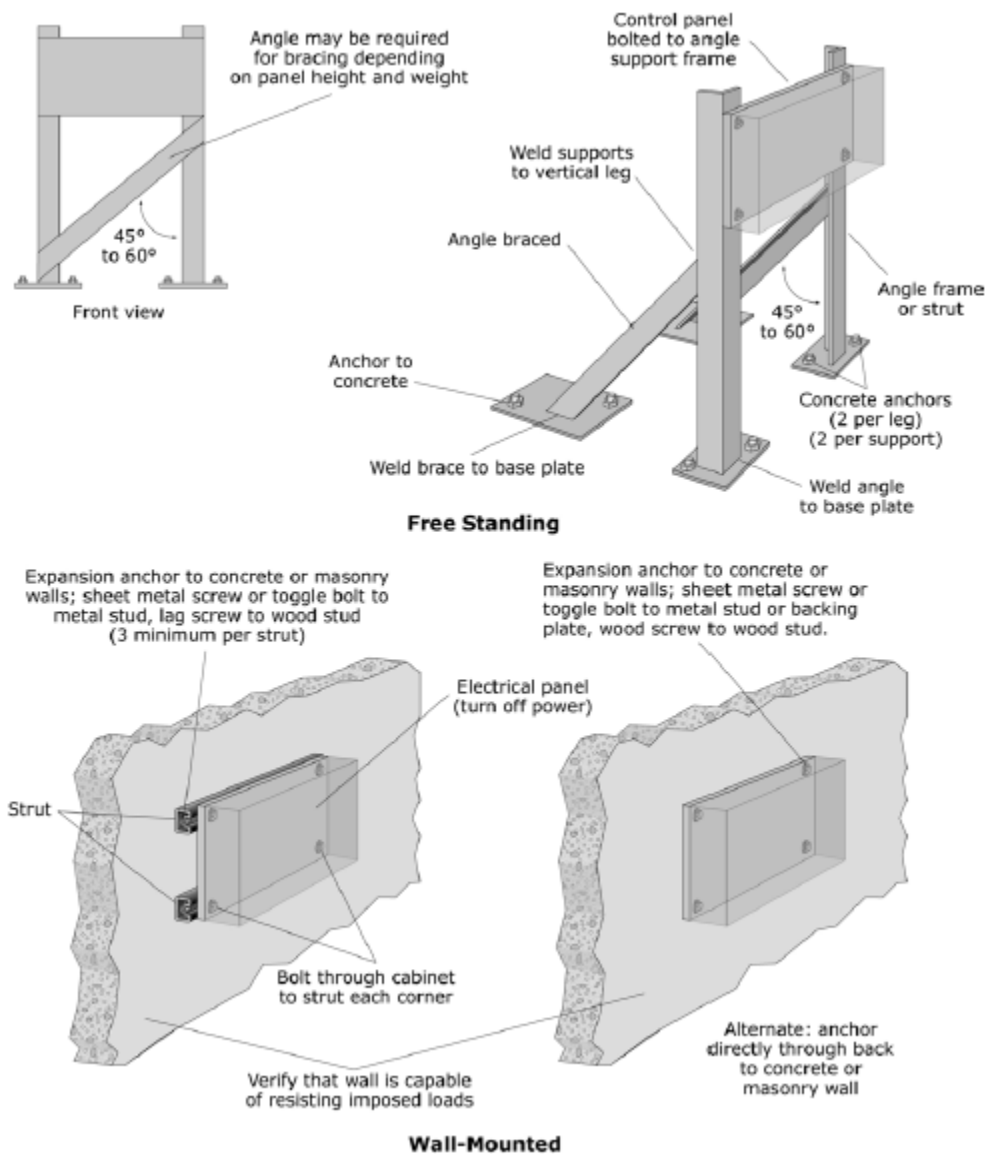


Figure G-39. Freestanding and Wall-mounted Electrical Control Panels, Motor Controls Centers, or Switchgear.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)

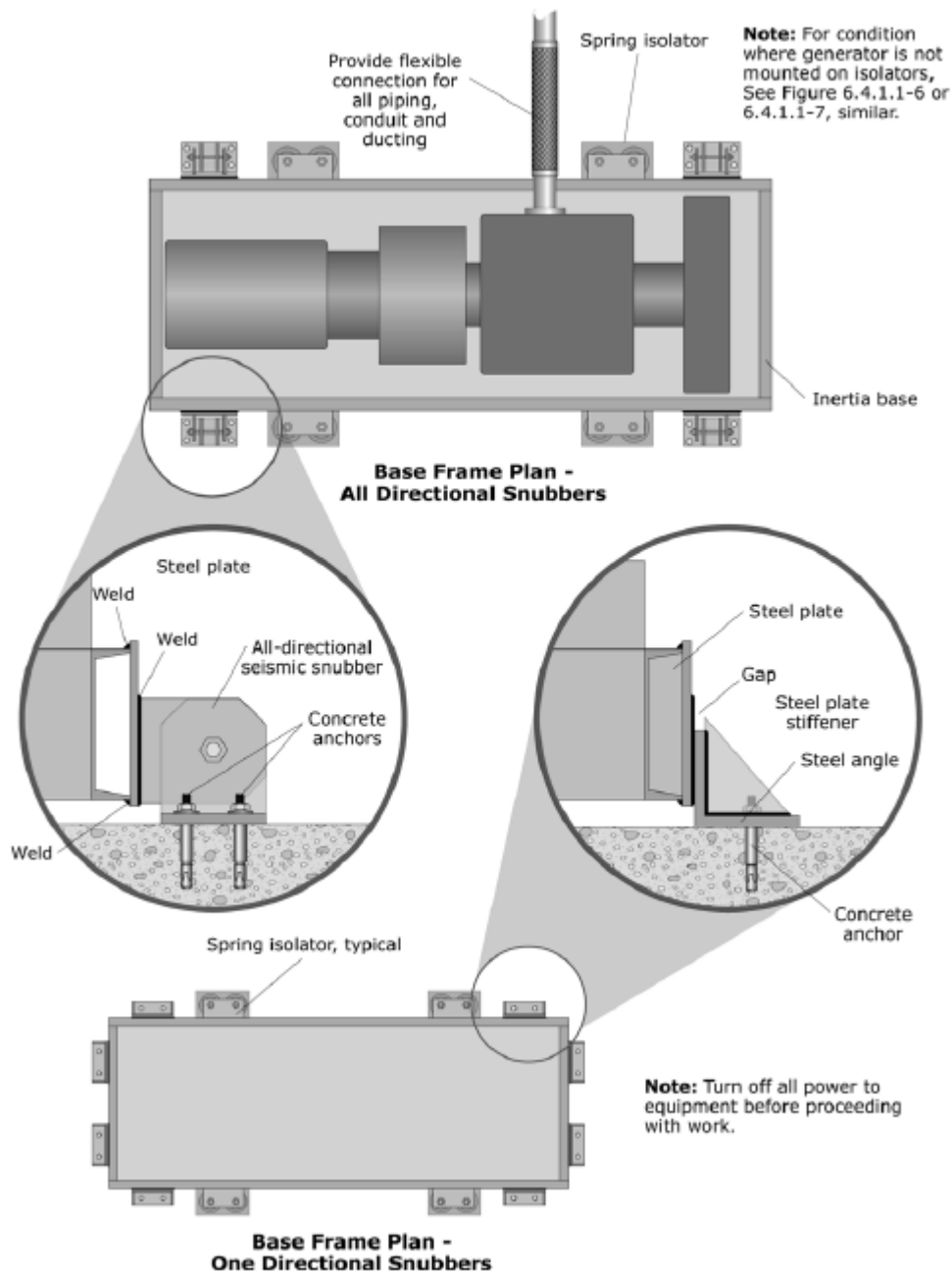


Figure G-40. Emergency Generator.
(FEMA E-74, 2012, Reducing the Risks of Nonstructural Earthquake Damage)